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FOCUS

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Exercise:
why science
says it doesn't
work

**TOMORROW'S GIANT
TELESCOPES REVEALED**

ON TEST: SMARTPHONES
THAT DO EVERYTHING

THE BIGGEST BREAKTHROUGHS OF

2012

As predicted by the world's top scientists including
Martin Rees, Susan Greenfield, Robert Winston,
Jim Al-Khalili, Jack Horner and more



The thinking city

Why Korea is building the most
high-tech place on Earth

NASA's tractor beam

How laser beams could gather
material from space (really!)



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Welcome

January 2012

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We start our first issue of 2012 as we mean to go on, by bringing you expert opinion from some of the world's greatest scientists. And what a line-up we

have: Susan Greenfield, Martin Rees and Robert Winston are among the luminaries giving their take on the year's biggest breakthroughs. So when you hear about the Higgs boson, cosmic background radiation or geoengineering, remember that you read it first in *Focus*.

Meanwhile, I'm delighted that one of Britain's best-known chemists, Dr John Emsley, has written our guide to the chemistry of Christmas.

It's certainly given me a new perspective on traditional festivities. Eat too much pudding, though, and you'll have to put 'losing weight' on your list of New Year's resolutions. Is exercise the answer? *Horizon* presenter Michael Mosley has some food for thought on page 45, while we test high-tech fitness gear on page 88.

As well as pledging to get fit, you might be thinking of taking up a new hobby. What

about astronomy? If you're fascinated by the night sky, you can find out more in a new season of *Stargazing LIVE*, which airs on BBC Two in January. We preview the show and reveal the incredible telescopes of the future on page 63.

Speaking of new technology, where do you think is the most high-tech place on Earth? With microprocessors embedded in buildings, vehicles and streets, it's been designed as a new kind of city. Turn to page 55 to find out more.

Finally, I'd like to tell you about an important change. On 1 November 2011, the licence to publish *Focus* magazine was acquired from

BBC Worldwide by Immediate

Media Company. For us, it's business as usual and we remain committed to making a magazine of the highest editorial quality, one that complies with BBC editorial and commercial guidelines and connects with BBC programmes.

Until next issue,

Graham



What I've found out this month

- When he ran for 10 minutes, *Horizon* presenter Dr Michael Mosley burned off just 80 calories, whereas a small chocolate bar has 240 calories (p46)
- The energy received by all the world's radio telescopes in the past 80 years is less than that required to boil a kettle (p66)

Experts



Charles Arthur
As *The Guardian's* technology editor, Charles Arthur has been keeping pace with the fast-moving world of tech for the last 16 years. Read his tour of the most high-tech place on Earth on page 55.



Michael Mosley
A qualified physician, Michael has worked on prestigious TV programmes such as *Newsnight* and *Horizon*. On p45 he looks at whether exercise really will help you shed those excess pounds.



Doctor John Emsley
Dr Emsley is the author of several acclaimed books on chemistry, including *Nature's Building Blocks* and *The Elements Of Murder*. On page 52, he turns his attention to the chemistry of Christmas.



Professor Sir Martin Rees
The Astronomer Royal, Sir Martin is also Master of Trinity College, Emeritus Professor of Cosmology and Astrophysics at the University of Cambridge, and the author of several books on astronomy.



If you enjoy our reviews and Q&A sections, you're sure to love *The Ultimate Gadget Guide 2011* and *The Big Book Of Answers*, both of which are on sale now.

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How to get in touch

Phone

Subscription enquiries (and back issues)
0844 844 0260*
Editorial enquiries
0117 314 7388
Advertising enquiries
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@ Email

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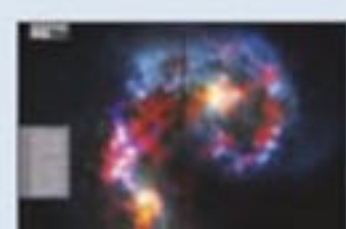
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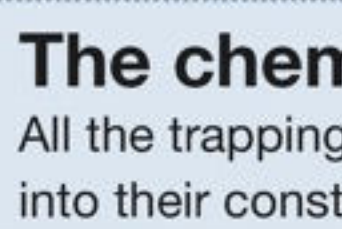
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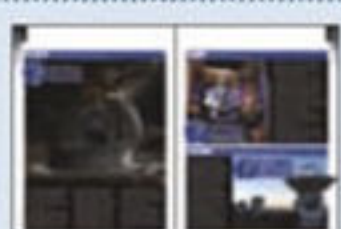
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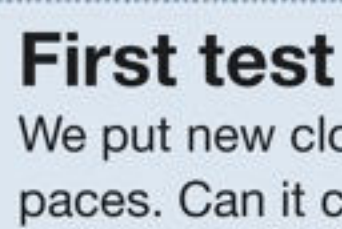
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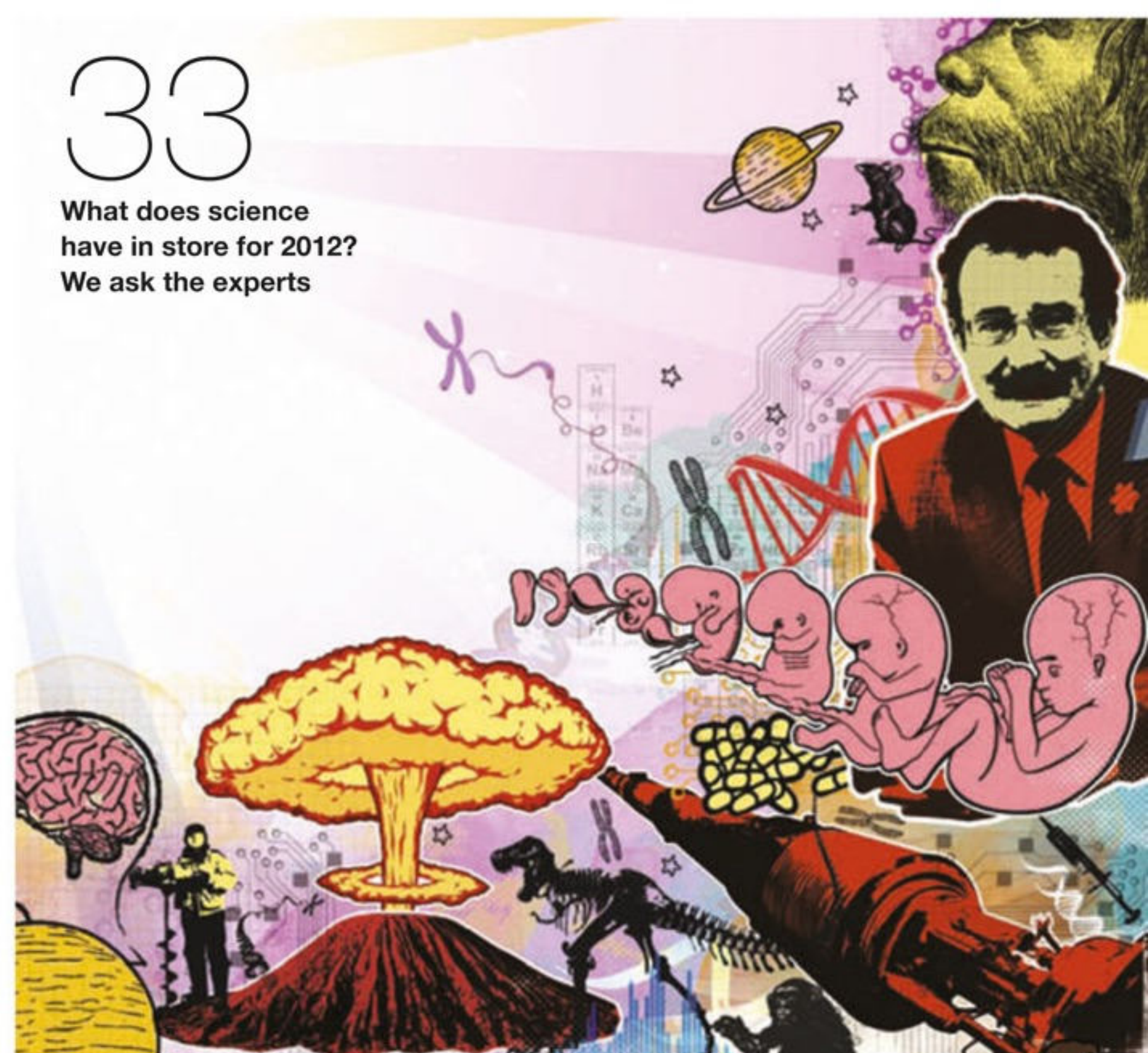


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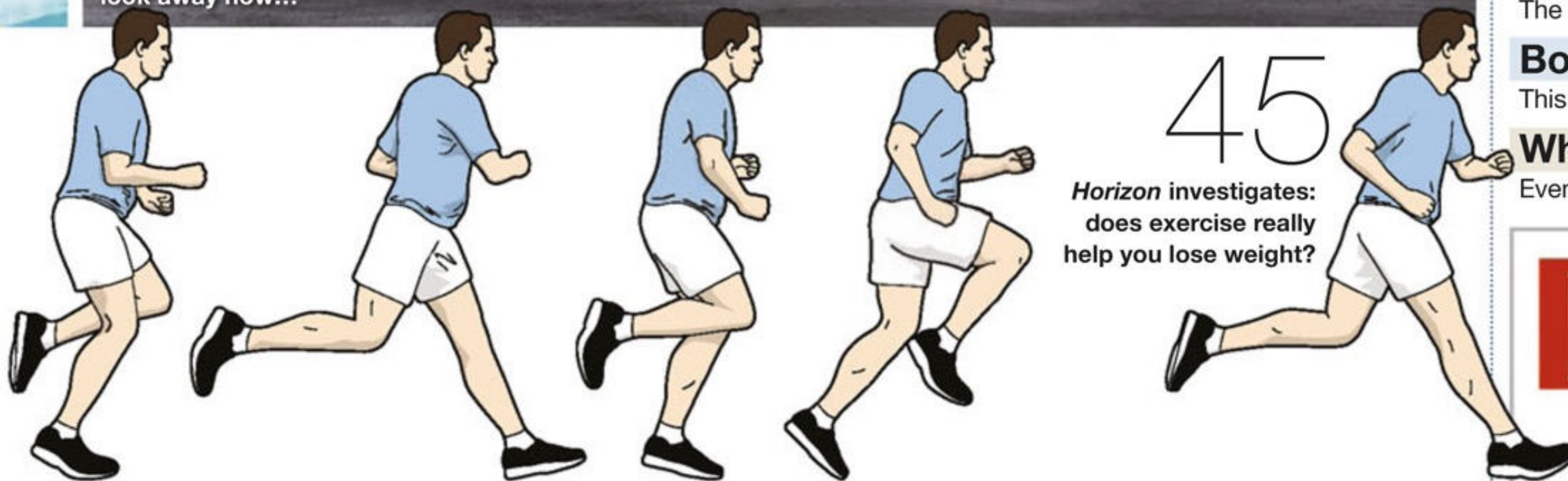
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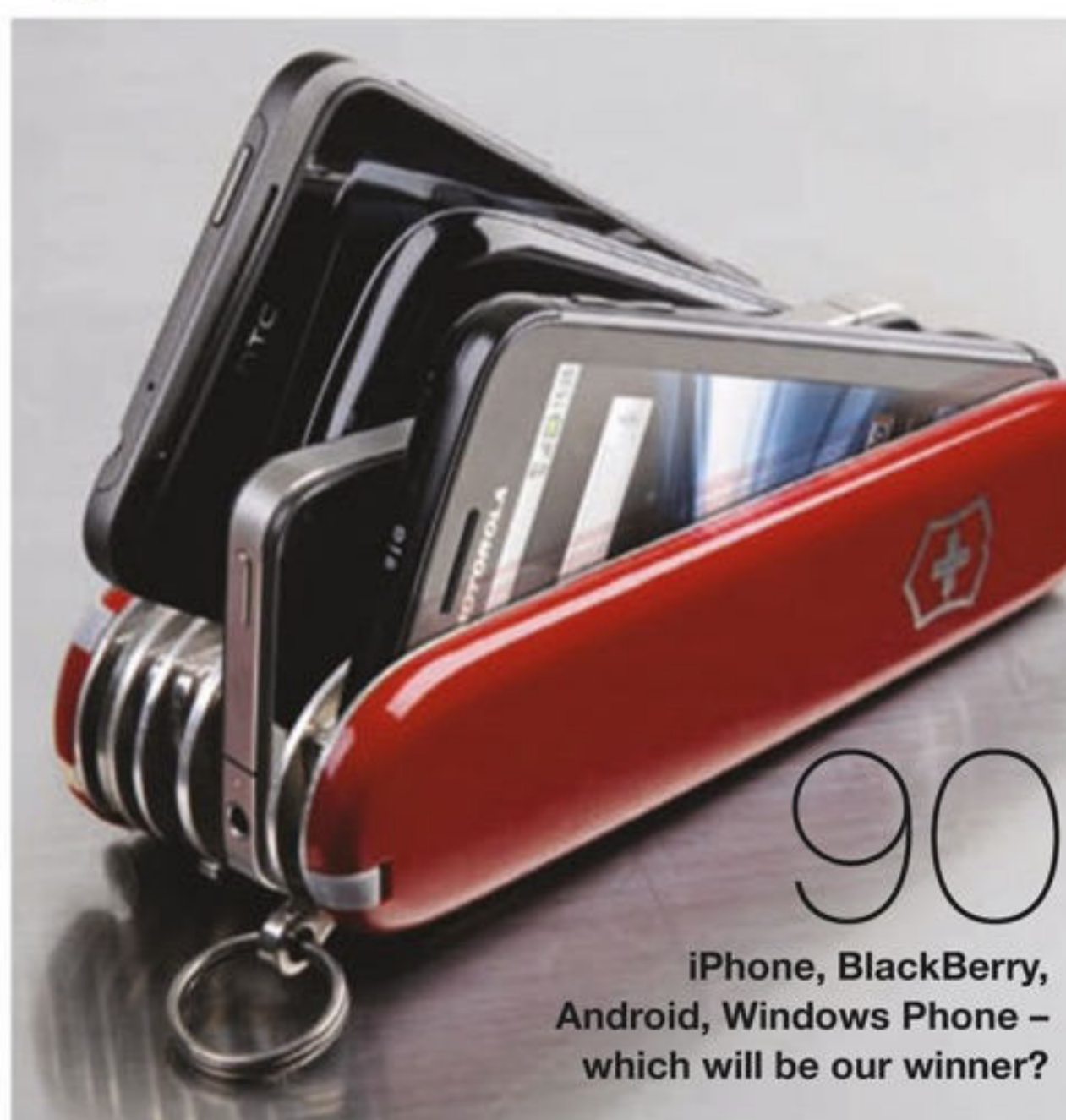


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Are You Buying Pre-Ruined

The Music Chain

Much is written about music and the musicians who entertain us, and we rightly exalt great musicians. But there is an interlinked chain of participants, two of which are I believe are crucial to our music scene in today's world. For centuries the music chain was a very short one – composers or songwriters, musicians and listeners, and the judgement on quality was immediate. Recording technologies have changed all this exponentially.

Today, we listen to most of our music from a recording and this gives recording engineers the opportunity to avoid poor acoustics, duff notes and off days. This, of course, means the chain has grown to include the recording engineers, the music distribution system (retailers or downloads), hi-fi manufacturers, hi-fi sellers and the hi-fi purchasers, the latter being the listeners. I should start by saying that hi-fi has become an adulterated term that no longer has its original meaning because it's applied to much equipment that certainly should not be termed high-fidelity.

It's said that a chain is only as strong as its weakest link. However, I believe there are two particularly strong links that, if removed from the chain, would seriously damage the quality of recorded music. These are the audiophile, or hi-fi connoisseur, and the specialist hi-fi retailer, the latter in nearly all cases also being the former because it's their interest that has driven them into their particular business. These are the people who most appreciate how exciting and involving music can be and how it can deliver an emotional experience.

Hi-Fi Connoisseurs

So why is the hi-fi connoisseur so important to the music industry? By their nature, audiophiles are generally avid music lovers who enhance their enjoyment through listening to music at its very best quality level, which means playing great recordings

through hi-end hi-fi to achieve the most outstanding results. Without the audiophile, the main driver for quality would probably be removed from the chain. Let's be honest, over recent years the majority of music listeners now settle for MP3 convenience and, therefore, mediocre sound quality, that is 'pre-ruined' music. If the pendulum ever swings so far that all but a few listen to highly compressed formats such as MP3, music producers will not waste their resources on producing high quality recordings because it would be commercially unnecessary, even if their recording engineers wanted to achieve the best they could. After all, an MP3 or AAC file, the iTunes default format, downloaded at 128 kbps (the most popular download speed), is about one-eleventh the size of a full resolution CD track, 1411 kbps, so the quality is inevitably far inferior. Information is irretrievably lost and the full dynamic range is lacking. Using an iPod while jogging does not really raise a quality issue but playing low-resolution tracks through an iPod docking station that feeds into a decent hi-fi system, is a disaster area. It's rubbish quality made louder. Fortunately, there is still significant demand from audiophiles committed to sound quality to sustain the production of high quality recordings, but it would be a tragedy if there weren't. For example, most classical recordings downloaded as an MP3 or AAC file are a complete waste of time because there is so much information missing that they are reduced to just the essence of a tune.

Specialist Hi-Fi Retailers

Just as essential a link in the chain as the hi-fi connoisseur is the specialist hi-fi retailer and the two are rightly dependent on each other. Without the specialist retailer the hi-end hi-fi manufacturer would have to rely on the internet and hi-fi magazine reviewers to try and assess the relative merits and

performance of their products against that of their competitors – a notoriously unreliable decision making process. Specialist hi-fi retailers are constantly being offered new products for assessment and potential stocking and, as it is also their hobby as well as their livelihood, they are greatly interested in achieving the best performance and seeking out the most outstanding products and combinations. More than that though is their relationship with audiophiles for, if they are to stay in business, they must satisfy the most discerning customers in the industry. The reality is that audiophiles and specialist hi-fi retailers are essential to each other.

Future of Recorded Music

What are the future prospects of maintaining high quality music recordings? We must hope that audiophiles, or hi-fi connoisseurs, or perhaps most accurately described, music lovers, will continue to drive the demand for quality. But another important reason for hope within the mass-market is that there is no longer any over-riding reason for MP3 and AAC to have such a following. These formats were designed to overcome very slow download speeds and expensive memory capacity. These are not significant factors for most people now. Full resolution, CD quality, downloads are already available and should become the norm as long as the general public can be made aware of the tremendous quality benefit. This has happened with HD TV so we know this awareness can grow rapidly. In the meantime, we must highly value hi-fi connoisseurs and specialist hi-fi retailers, of which the ones listed on this page represent the UK's finest. Specialist dealers know how to choose the products that combine as a superb system and how to get the best out of it by expert installation in the home. If there's a price premium over an internet purchase, it's probably a small one, but it's unquestionably worth the difference.

Music?



The specialist dealers below have been selected because they are known to do an excellent job in guiding customers towards hi-fi that will give years of musical enjoyment and total satisfaction.

OUR TOP 20 UK HI-FI DEALERS

SOUTH

Ashford, Kent

SOUNDCRAFT HI-FI
40 High Street.
t: 01233 624441
www.soundcrafthi-fi.com

Chelmsford

RAYLEIGH HI-FI SOUND & VISION
216 Moulsham Street.
t: 01245 265245
www.rayleighhi-fi.com

Colchester

NEW TECHNOLOGY UNLIMITED
33 Sir Isaac's Walk.
t: 01206 577682
www.newtechnologyunlimited.com

Kingston-upon-Thames

INFIDELITY
9 High Street,
Hampton Wick.
t: 020 8943 3530
www.infidelity.co.uk

Maidenhead

AUDIO VENUE
36 Queen Street.
t: 01628 633995
www.audiovenue.com

Rayleigh, Essex

RAYLEIGH HI-FI
44a High Street.
t: 01268 779762
www.rayleighhi-fi.com

Southend-on-Sea

RAYLEIGH HI-FI SOUND & VISION
132/4 London Road.
t: 01702 435255
www.rayleighhi-fi.com

LONDON

Ealing

AUDIO VENUE
27 Bond Street.
t: 020 8567 8703
www.audiovenue.com

N1

GRAHAMS HI-FI
190a New North Road.
t: 020 7226 5500
www.grahams.co.uk

SW11

ORANGES & LEMONS
61/63 Webbs Road.
t: 020 7924 2043
www.oandlhifi.co.uk

SW20

O'BRIEN HI-FI
60 Durham Road.
t: 020 8946 1528
www.obrienhi-fi.com

SOUTH WEST

Bath

AUDIENCE
14 Broad Street.
t: 01225 333310
www.audience.org.uk

Exeter

GULLIFORD HI-FI
97 Sidwell Street.
t: 01392 491194
www.gullifordhi-fi.co.uk

MIDLANDS

Banbury

OVERTURE
3 Church Lane.
t: 01295 272158
www.overture.co.uk

Birmingham

MUSIC MATTERS
363 Hagley Road, Edgbaston.
t: 0121 429 2811
www.musicmatters.co.uk

Coventry

FRANK HARVEY
163 Spon Street.
t: 024 7652 5200
www.frankharvey.co.uk

Leicester

CYMBIOSIS
6 Hotel Street.
t: 0116 262 3754
www.cymbiosis.com

Nottingham

CASTLE SOUND & VISION
48/50 Maid Marian Way.
t: 0115 9584404
www.castlesoundvision.com

NORTH

Cheadle

THE AUDIO WORKS
14 Stockport Road.
t: 0161 428 7887
www.theaudioworks.co.uk

Chester

ACOUSTICA
17 Hoole Road.
t: 01244 344227
www.acoustica.co.uk

Hull

THE AUDIO ROOM
2 George Street, Hedon
t: 01482 891375
www.theaudiroom.co.uk

York

SOUND ORGANISATION
2 Gillygate.
t: 01904 627108
www.soundorg.co.uk

STAR QUALITIES

VALUE FOR MONEY ★ ★ ★ ★ ★
SERVICE ★ ★ ★ ★ ★
FACILITIES ★ ★ ★ ★ ★
VERDICT ★ ★ ★ ★ ★



First light

This collection of stars and gases is actually two colliding galaxies. The Antennae Galaxies, which are 45 million light-years away, are slowly joining to become one giant galaxy. They can be seen as never before thanks to a new telescope facility in northern Chile, the Atacama Large Millimeter/sub-millimeter Array, or ALMA for short.

Most of this image – the first ALMA has taken – was created with just 12 of the 66 radio antennas that will eventually make up the array. The antennas detect much longer wavelengths than visible light. “The ALMA data is in red and yellow,” says Dr Leonardo Testi, an ALMA project scientist. “In both cases, this is interstellar gas, and is where we think stars are forming.” The other part of this composite image (in blue) was taken by Hubble Space Telescope using visible light and shows stars within the galaxies.







Going with the flow

It looks like a scene from an environmental disaster but the green liquid seen here gushing down a fissure on Switzerland's Plaine Morte glacier is actually just melt water with fluorescein, a fluorescent dye, added.

Scientists from the universities of Bern, Fribourg and Lausanne, in collaboration with the Swiss Institute of Speleology and Karstology (SISKA), which studies caves and geological formations, have introduced the dye to find out where the melt water runs when it dips beneath the ice.

"The dyes we use are completely harmless – they're also used in medicine," says Professor Rolf Weingartner at the University of Bern, a leading scientist on the project.

The team hopes that tracking the melt water will help them develop a sustainable management programme for the glaciers.

Monster mouth

The mouth of the common housefly (*Musca domestica*) looks even weirder when seen in extreme close up.

The brown translucent region is actually two structures called labella that sit at the end of the fly's long proboscis. Salivary secretions from the labella help to dissolve and collect particles of food, which are then taken up by the tiny tubes called pseudotrachea.

This image, taken by Dr Havi Sarfaty of the Israel Veterinary Association with a polarised light microscope, won a distinction in the 2011 Nikon Small World competition. It shows a fly's labella magnified 100 times.

"Under such magnification," says Sarfaty, "it's not possible to see the image sharp enough, so I used a technique called focus stacking, which makes several images (in this case 200) and combines them."







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January 12

The latest intelligence

Need to know

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NASA investigates 'tractor beams'

Space agency looks at laser technology to capture samples



Future NASA missions may use tractor beams – lasers that can trap and move objects – to remotely gather samples for analysis. Grabbing hold of spacecraft with lasers will remain the stuff of *Star Trek*, but the US space agency has handed out \$100,000 (£62,650) for an investigation into the best available methods to collect samples in space.

"Experiments have shown that laser-based trapping of particles is not beyond us," says Dr Paul Stysley, principal investigator on the tractor beam research group at NASA's Goddard Space Flight Center in Maryland. "If we can figure out the best way to do it, then scale it up, we could collect samples from, say, comet tails over greater distances and longer time periods than is currently possible."

Using tractor beams, an orbiting spacecraft could potentially trap samples

from a planet's upper atmosphere, or a lander could trap them from the ground or lower atmosphere. These samples, ranging from particles to individual molecules, would then be corralled into an instrument for analysis.

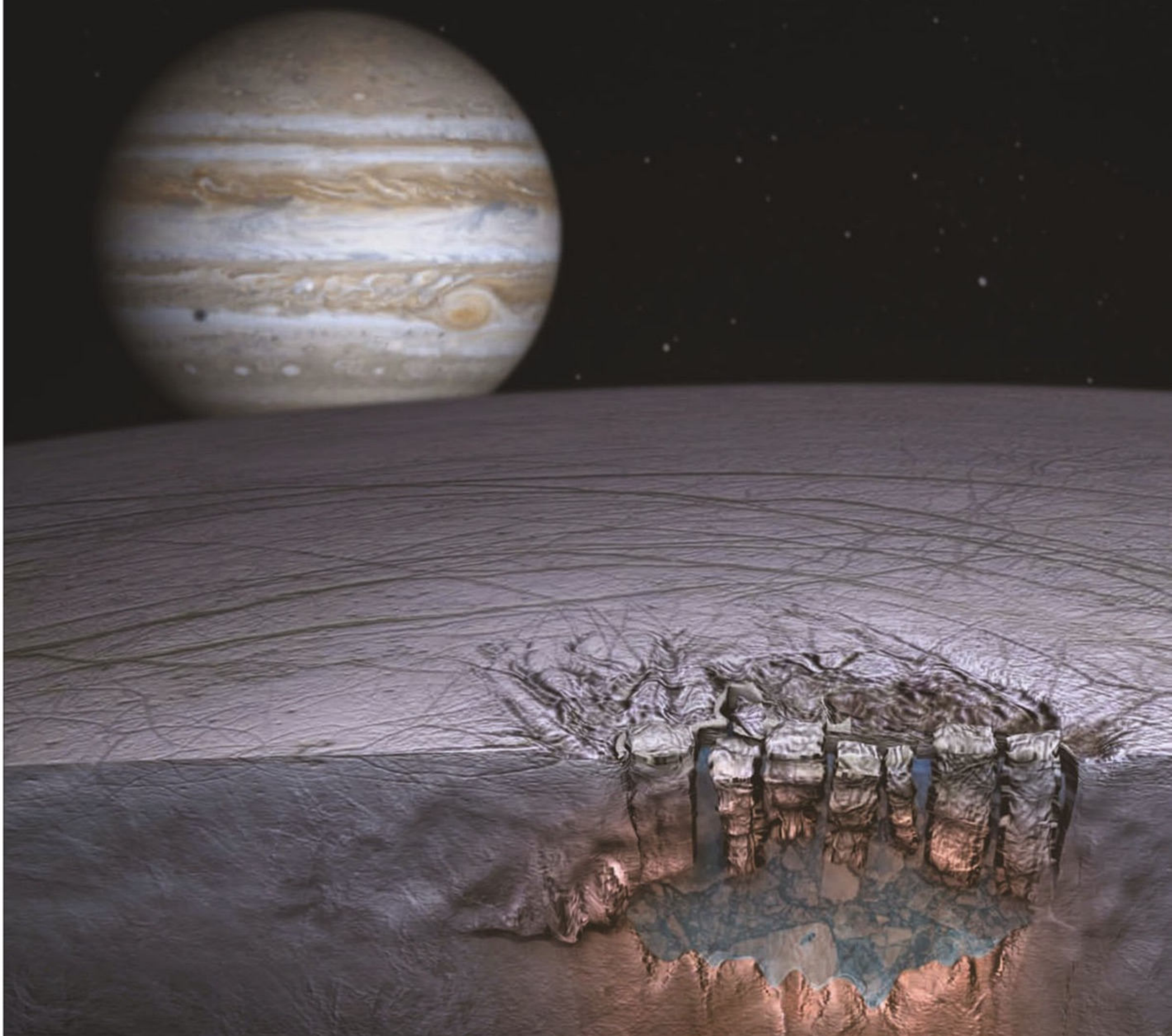
The first technique being explored involves 'optical tweezers' – a technology already used on Earth. Another involves optical solenoid beams, while a third involves a Bessel beam (see right for more details). But these are still early days.

"Just trying to move tiny particles at the distances required for sample collection is an ambitious goal, which is probably 10 years away," says Stysley.

The original idea was to use tractor beams for cleaning up orbital debris. But to control something so large was beyond current technology, so sample collection was suggested as an alternative.

Tractor techniques

NASA's tractor beam research group is looking at three methods. 'Optical tweezers' have two intersecting laser beams that create a ring-like electrical field within which particles are trapped. Strengthening or weakening one of the beams can move the particles, but this requires an atmosphere, so it could only work on some planets. A second method uses optical solenoid beams, in which the intensity of the light peaks in a spiral pattern along the beam's length. This spiral can exert a force that sends particles towards the beam's source. In the third technique a Bessel beam is used – if shone on a wall, this would appear as rings of light around a central dot. The idea here is that light scattered ahead of an object by the beam could pull it backwards.



Life beneath Europa?

Evidence for a large body of liquid water trapped inside the icy shell of Europa, a moon of Jupiter, could be significant in the hunt for life in the Solar System.

The lake (pictured above in an artist's impression), holds as much water as the North American Great Lakes and could be one of many in the icy crust. It came to light in a new analysis of data collected by NASA's Galileo spacecraft in the 1990s.

The notion of liquid water on Europa isn't new. It's long been thought that a seawater ocean lurks beneath Europa's icy shell, spanning the entire moon.

But if the ice shell was thick, it might have scuppered the chance of life existing because there'd be no way for nutrients and energy to be transferred between the surface and the ocean beneath.

The new research shows that the lake is covered with ice shells that are collapsing. "We see evidence that even though the ice shell is thick, it can mix vigorously," says lead researcher Britney Schmidt of The University of Texas at Austin.

The research compared bumpy features on Europa's surface to glaciers on Earth to find out how they form.

44
thousand
years is the
age of a piece
of jawbone
excavated from
a cave in Torquay
– the earliest
evidence yet of
modern humans
in Europe

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is the weight that would be added to a 4GB Kindle ebook reader if it was filled to capacity, a scientist in California has calculated. The weight is due to the energy required to hold electrons in a fixed place, storing data

13 bottles is the amount of wine you'd need to drink to consume the same amount of resveratrol as a 150mg tablet. Resveratrol has health benefits such as lowering cholesterol



Studying the DNA of long-lived humans may provide clues as to how diseases are avoided

Geneticists compete for share of \$10m prize

Race is on to read 100 genetic codes in 30 days

The entire genetic codes of 100 healthy centenarians are to be sequenced in research that could improve our chances of living longer. Teams of geneticists have been challenged to read 100 genetic codes in just 30 days.

Those that manage to read the 100 codes in a month will be handed a share of the \$10 million (£6.3 million) 'incentive' in the Archon Genomics X PRIZE. They will start their gene-reading race on 3 January 2013, analysing the same DNA samples and facing a deadline of 3 February.

To qualify for the money, the teams must satisfy some stringent rules. For each 1,000,000 bases or 'letters' that make up the genetic code, there can only be one error. And it must cost the teams no more than \$1,000 (£630) to sequence each individual's genetic code. The first three teams will share the prize. The aim of the competition is to study healthy individuals with 'good genes' that have helped them evade diseases linked with ageing.

“Centenarians for one reason or another were able to either evade life-threatening diseases such as cancer, cardiovascular disease and diabetes, or overcome them,” says Grant Company, senior director of the Archon Genomics X PRIZE. “Our aim is to help researchers gain deeper insights into the underlying biology of their longevity by providing these highly sequenced genomes to the research community.”

The competition is the latest to be organised by the X PRIZE Foundation, a Californian non-profit organisation that develops technological challenges for the benefit of mankind, each with a hefty prize fund. Past competitions have included the Ansari X PRIZE for building a viable private spacecraft.

When the contest ends, the data will be made available to the wider scientific community, yielding what Company calls, “the most highly and perfectly sequenced database of human genomes ever assembled”.

Lasers can detect counterfeit whisky. Physicists at Scotland's University of St Andrews have found that by shining a laser through a whisky sample and analysing the scattered light, they can determine its alcohol content

The Burmese python's heart grows healthily after the reptile has eaten a fatty acid mixture. Scientists are studying the mixture to find out if it could be useful in developing treatments for heart disease.

A new test that determines how close cancer cells are to 'natural' death appears to provide a clear indication of how responsive they would be to chemotherapy, US research shows

GOOD NEWS BAD NEWS

Laundry lint is finding its way into our oceans. Ecologists led by Dr Mark Browne at University College Dublin took samples from 18 beaches on six continents. All the samples contained filaments made of polyester or acrylic, compounds found in textiles

New US research shows how quickly bacteria can pick up new genes, some of which may help them resist antibiotics. Biologists found a huge network of horizontal gene transfer, the process by which a bacteria gains genetic material from another without being its offspring

The antibiotic oxytetracycline used to treat honey bees may be weakening their resistance to pesticides, University of Maryland entomologists have discovered

INSIGHT

Stretchable touch-sensitive materials**What's this all about?**

Researchers at the University of Munich are developing a new type of touch technology that could lead to everyday items like clothes, headphone wires and coffee tables becoming touch-sensitive, just as tablet computers are now.

How would it work?

It's an adaptation of time domain reflectometry (TDR), a technique used to detect damage in underwater cables. A short electrical impulse is sent down a cable and partially bounces back when it reaches a defect. The position of the problem area is calculated based on the speed of the pulse and the time it takes to travel back.

How would that apply to clothes?

With the new approach, copper wires or strips of foil are incorporated in the material and connected to a pulse generator and detector. Tiny electrical impulses are sent down the wire or strips. When a finger touches the wires it alters their capacitance (charge-holding capacity). This acts in the same way as a defect in an undersea cable.

Unlike an iPhone, which uses a matrix of wires, the German system requires a single pair, which can be configured in different patterns.

When can we expect to see touch-sensitive t-shirts?

The set-up is currently rather cumbersome, but the researchers are already working on ways to shrink the processing part of the system down from a computer to a single chip. Once they do, 'smart' clothes won't be far off.



Touch-sensitive materials could soon be used in everything from t-shirts to coffee tables

ROUND UP

This month's top science stories from around the globe

SPACE

Why black holes are hidden

Dust clouds that obscure supermassive black holes at the centres of galaxies could be the result of high-speed collisions between planets and asteroids, according to a new theory from an international team of astronomers. Around half of all supermassive black holes are hidden by dust shrouds. The new theory proposes that at the centres of galaxies there are planets and asteroids, colliding with each other at up to 1,000km (620 miles) per second, creating particles of dust.

ANIMAL BEHAVIOUR

Orcas go for spa breaks

Antarctic killer whales may migrate to warmer waters for spa-like skin treatments. Scientists at the US National Marine Fisheries Service monitored orcas as they travelled over 8,000km (5,000 miles) to southern Brazil, where they stayed for just 42 days before returning. There was no interruption in speed or direction to suggest they were foraging for food or giving birth. But the scientists did observe that a yellowish skin coating caused by algae had disappeared by the time they left.

PHYSIOLOGY

How lions get their roar

Lions' and tigers' fearsome roars are due to the unusual shape of their vocal chords, according to new research by US biologists. Until now it was thought that the big cats' roar was down to thick layers of fat inside their vocal chords which make them bulkier. But this new research suggests that it's the square shape of the chords that is key, because it can better withstand stretching. This allows for the production of louder noises at lower lung pressures. Vocal folds are typically triangular.

HEALTH

Skin 'sees' the light

Human skin detects ultraviolet (UV) radiation and triggers the production of melanin, thanks to a photoreceptor previously found only in the eye. Researchers at Brown University in Rhode Island in the US identified photoreceptors known as rhodopsins – known to detect light in the retina – in melanin-producing skin cells known as melanocytes. When exposed to sunlight, these rhodopsins release calcium signals that trigger the production of melanin, the pigment that protects skin from UV damage.

ENVIRONMENT

Heat island effect is small

Environmental engineers have calculated the global warming caused by 'heat islands' around busy cities. They conclude that these islands' impact is modest, accounting for only two to four per cent of gross global warming since the Industrial Revolution. Heat islands are caused by replacing soil and vegetation with paved roads and buildings, which reduces evaporation and warms cities. The darker colour of buildings compared to plants also means more of the Sun's energy is absorbed.

ARCHAEOLOGY

Future fossils eaten by worms

Bone-eating worms may have destroyed many of the world's fossil records by devouring vast numbers of bones before they had the chance to fossilise. Traces of *Osedax* worms have been found on a three-million-year-old fossil whale bone from Italy – the first time *Osedax* has been found in the Mediterranean. *Osedax* had previously only been found in whale bones from the US Pacific coast, so the new finding demonstrates that it was active over a large area.





Why are some sounds, such as fingernails on a chalkboard, excruciating? Musicologists believe they have found the answer. The researchers from Germany and Austria modified recordings of fingernails and chalk by removing or attenuating various frequency ranges. They found that the frequencies responsible for making a sound unpleasant were in the range of 2,000 to 4,000 Hertz. That is within the span of human speech, which ranges from 150-7,000 Hertz. The experts believe the human ear canal amplifies sounds made at the offending frequencies to painful effect.



Dr Ioannis Ieropoulos of UWE is working on ways to generate energy from human waste

The lion's ferocious roar has its origins in the unusual shape of the big cat's vocal chords



ENERGY

Pee can provide power

Urine could be a new source of electricity. Scientists at the University of the West of England in Bristol are investigating using urine in microbial fuel cells. In these cells, microorganisms like bacteria live in the anode. They oxidise a fuel source, in this case urine, producing electrons through anaerobic (without oxygen) respiration. The electrons move to the cathode and electricity is generated. Combining many such cells could produce sufficient power for a home or small village, say the researchers.

NEUROLOGY

Friendship alters the brain

Having a wide circle of friends could cause certain parts of your brain to grow, according to a new study. Scientists at the University of Oxford and Mount Sinai School of Medicine in New York studied the brains of macaque monkeys that lived by themselves, with a friend or in a small group. Their findings revealed that the monkeys that lived in a more social setting developed more grey matter in areas of the brain that are associated with processing social information, such as the rostral prefrontal cortex.

NEWS IN BRIEF

A Russian spacecraft bound for the Martian moon Phobos ground to a halt in Earth orbit when its second stage rocket failed to fire. Roscosmos, the Russian space agency, had hoped the Phobos-Grunt craft would return samples from the planet's surface, a feat NASA has yet to achieve. But the rocket failure left the £103 million mission stranded with full fuel tanks. As *Focus* went to press, a tracking station in Australia had re-established contact with the stricken probe, although it was still unclear whether or not its rocket could be reactivated.

Just how birds are able to dart through narrow spaces has been discovered. When an animal moves forwards, distant objects appear to move more slowly than closer objects and it is this phenomenon that birds employ. Using budgerigars trained to fly down corridors, Australian scientists found that if a bird spots one wall moving faster than the other, indicating it is closer, they will adjust to balance the speed of both walls.



The physicists who found that neutrinos apparently travel faster than light have carried out an improved experiment – and confirmed the result. Members of the OPERA collaboration fired neutrinos from CERN in Geneva to a detector at the INFN-Gran Sasso lab in Italy and this time they released shorter neutrino bunches, making it easier to identify when they had left. The idea that nothing can travel faster than light is set out in Einstein's theory of special relativity. In spite of the findings, other sources of uncertainty would have to be eliminated from the measurements before it's accepted that neutrinos can indeed break the 'speed limit'.

Scientists have borrowed from nature to build a tank-like robot that can scale smooth walls. Drawing inspiration from the gecko, the 'Timeless Belt Climbing Platform' has adhesives that mimic the toe-pads of the lizard. The device created at Simon Fraser University in Burnaby, Canada could be used to inspect pipes and power plants, and for search and rescue operations.



What happened to the Ice Age megafauna?

Woolly mammoths, woolly rhinos and other beasts that died out after the last Ice Age each succumbed to a different set of circumstances, a new study has revealed. Each of the six species investigated survived the Pleistocene Epoch, a geological period characterised by climatic fluctuations. So why did the luck of some of them change after the last Ice Age, 20,000 years ago? Previously, some scientists concluded that humans hunted them to extinction while others blamed climate change.

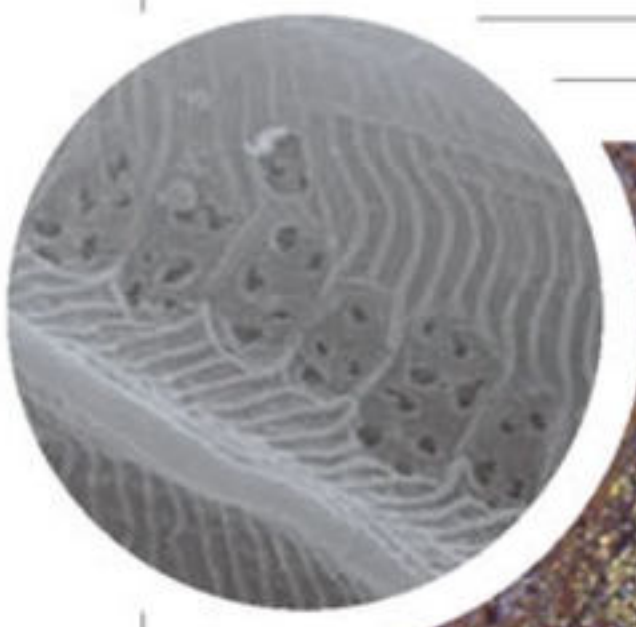
Researchers from China, Australia, Europe and the US looked at fossilised bones, archaeological records and DNA samples of woolly rhinos, woolly mammoths and wild horses, plus three species that survived – bison, reindeer and musk ox. They found a

complex picture in which climate and human influence played different roles in species' demise. In the case of the woolly rhino, the research showed that their ranges never overlapped with humans, so in this case climate change was the main factor. Other species, such as reindeer, managed to find refuge when the climate changed. The study suggests it could be more difficult than previously thought to predict the fate of species that are currently at risk.

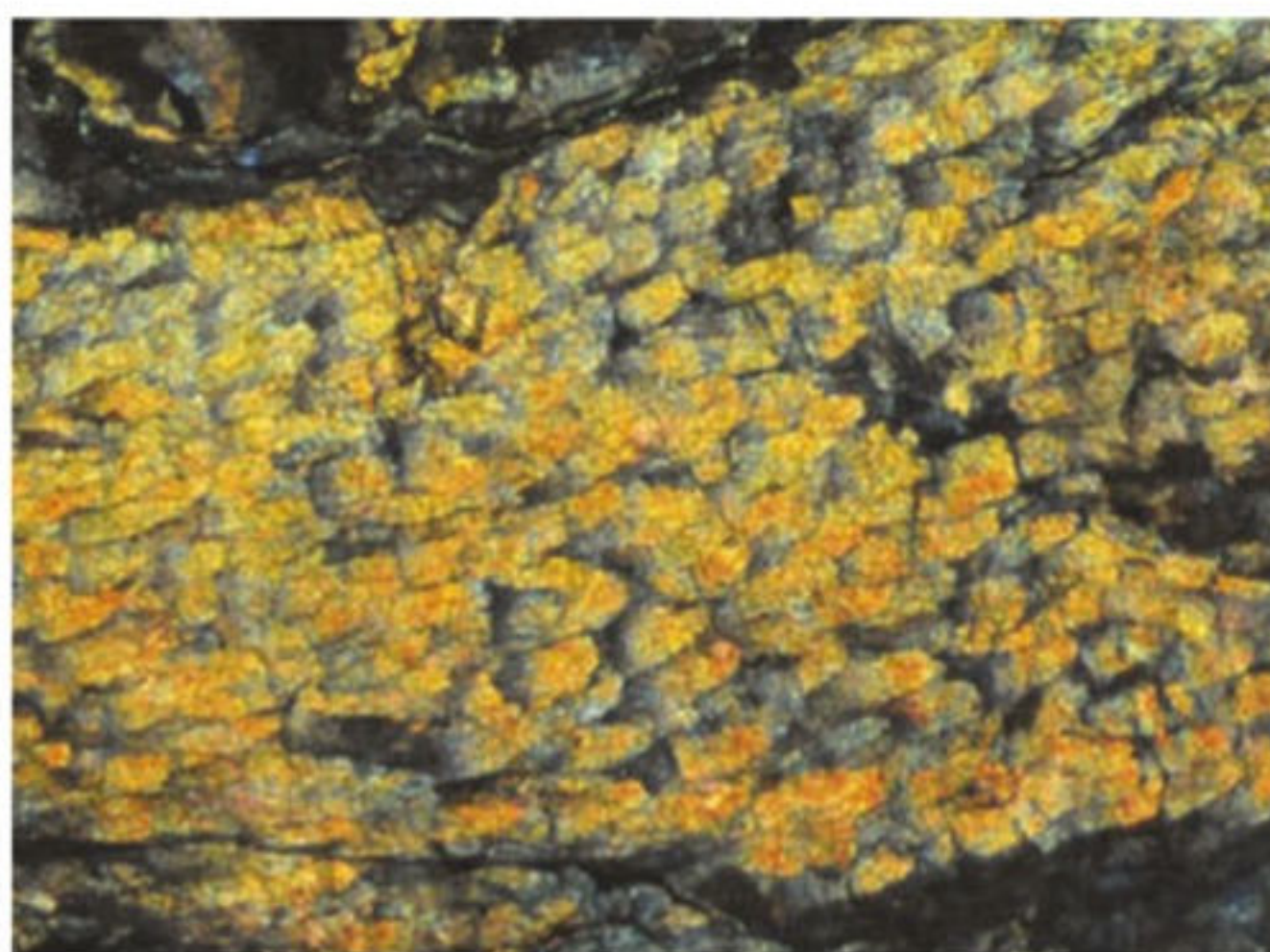
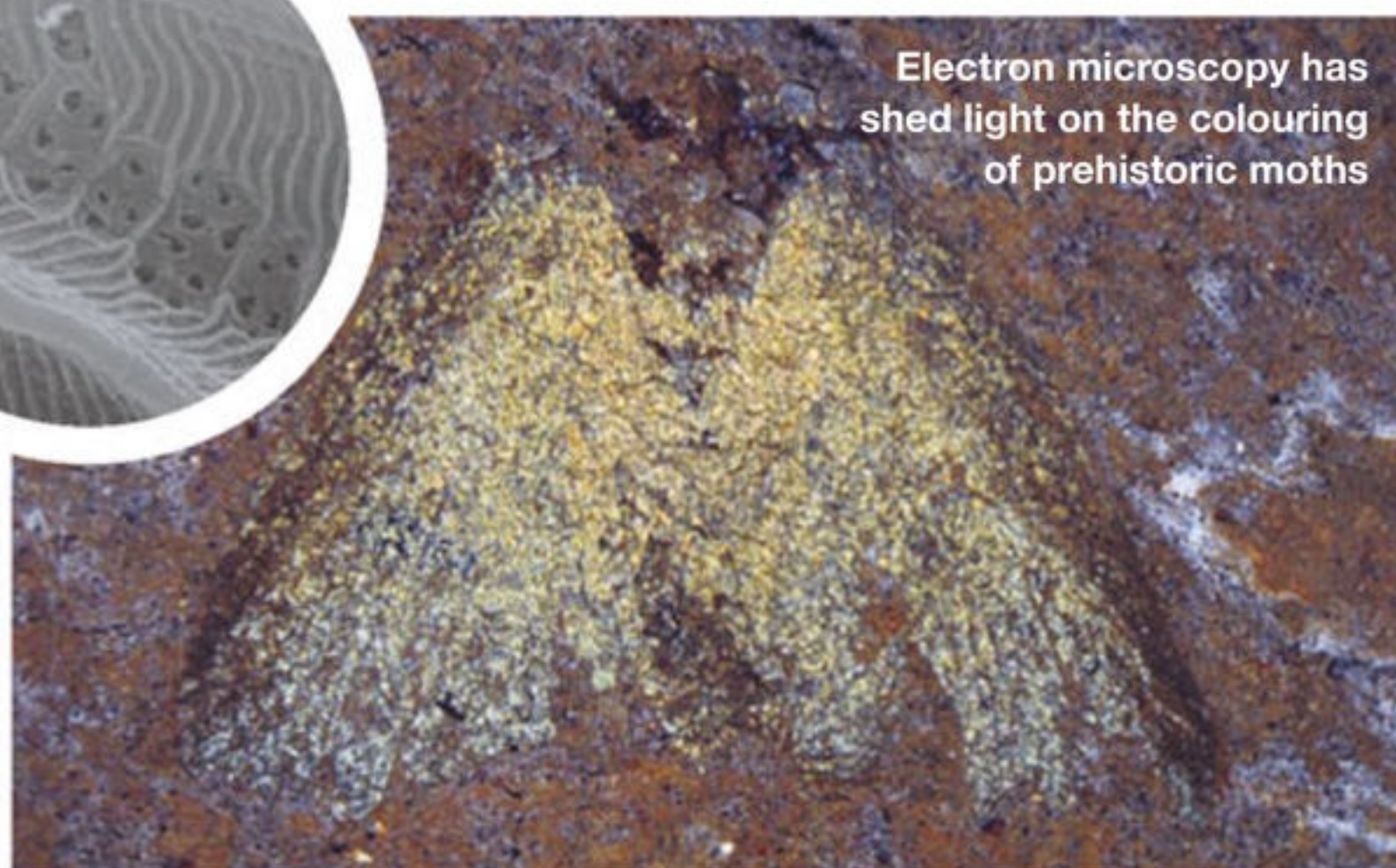
"This puts an end to blaming one factor or another," says study co-author Eline Lorenzen, a palaeogeneticist at the University of Copenhagen. "The fact that we see species-specific responses suggests we cannot generalise about how different species will respond to climate change."



Woolly mammoths were one of several species to die out after the last Ice Age



Electron microscopy has shed light on the colouring of prehistoric moths



Ancient moths glowed green

The wing colour of moths that lived 47 million years ago has been reconstructed thanks to some well-preserved fossils and a powerful microscope. US and German palaeobiologists studied fossils from central Germany whose wing scales still have a metallic gleam to them.

Using electron microscopy they were able to look at the detailed structure of the wings. Moths, birds and butterflies use 'structural colours' to create their sometimes stunning displays: grooves and other structures reflect light in certain ways to produce different colours and effects.

The pattern of veins in the German fossils' wings indicate that they would have had a yellow-green hue. Their closest living relatives are forester moths, which also have a metallic shine to their wings. The colouration could have acted as a warning to predators that they wouldn't taste very nice.

LOOK BACK

70 YEARS AGO
Ford patents a new car body material made by adding soya bean flour to plastics. Metal is in short supply and it is hoped the soya bean plastic will provide a tough alternative.

50 YEARS AGO
NASA launches unmanned space probe Ranger 3. Its mission is to transmit pictures of the Moon's surface, but it misses its target by 35,000km.

A portrait of actor Ryan Reynolds in a dark brown suit, white shirt, and dark tie. He is looking directly at the camera with a serious expression. His hands are clasped in front of him.

BOSS
HUGO BOSS

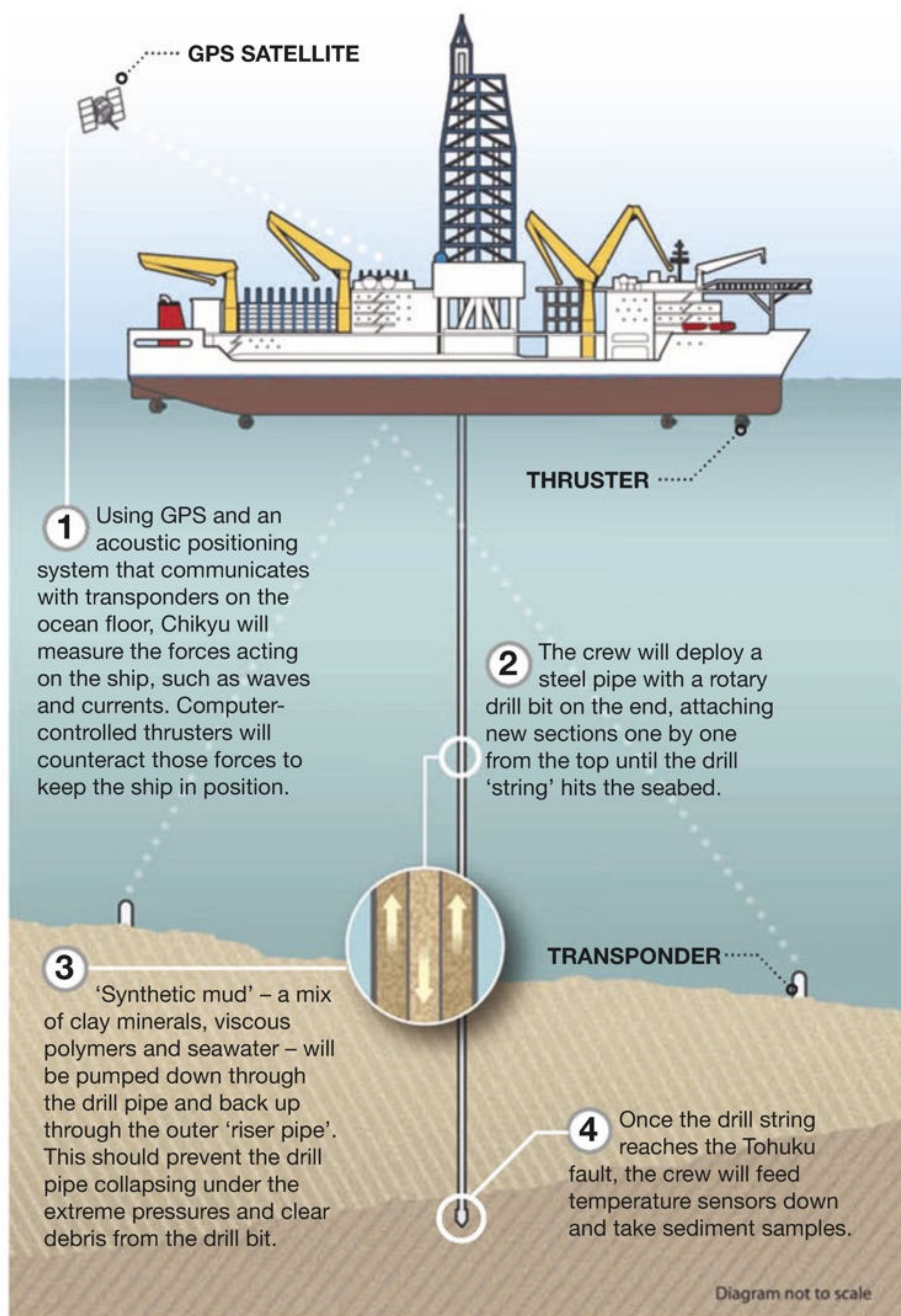
BOSS. BOTTLED.
THE NEW FRAGRANCE FOR MEN
FEATURING RYAN REYNOLDS



PREPARED FOR THE DAY. READY FOR THE NIGHT. BOSS BOTTLED,
AND NEW BOSS BOTTLED. NIGHT. FRAGRANCES FOR MEN.

Probing tsunami's source

Ship will drill into epicentre of 'quake behind Japanese tragedy



Japan is to deploy its drilling ship, Chikyu, to bore into the Earth's crust and take measurements near the underwater epicentre of the magnitude-9 Tohoku earthquake that led to 2011's devastating tsunami. Through the Japan Trench Fast Drilling Project, seismologists hope to understand a fundamental question – how two tectonic plates can slip tens of metres past each other. In the Tohoku earthquake, the tectonic plates slipped by 50 metres.

The friction of tectonic plates slipping past one another is dissipated as heat. Once Chikyu's drill reaches the fault, temperature sensors will be dropped into the rock. By measuring temperature changes for up to three years, researchers will be able to calculate the total amount of heat generated by the quake, and therefore the resistance forces when the plates slipped – an important insight into the mechanism that created the tsunami.

Sediments will also be extracted so their texture can be examined. Some, such as round clay particles, may help tectonic plates slip past each other.

Chikyu will set sail in April.



...and finally

Meteorite is a rare (and valuable) find

When a farmer discovered a meteorite buried in a hillside in the town of Conception Junction, Missouri, in 2006, little did he realise just how rare it was. The 17kg meteorite, acquired by a

group of amateur collectors, is only the 20th pallasite (fragment of a large asteroid) found in the US. It consists of green olivine crystals embedded in iron-nickel rock. It's thought to come



from the boundary between the asteroid's metal core and its olivine lower mantle. Once polished, the Conception Junction meteorite is worth between £19 and £32 a gramme. Common meteorites sell for between £1.30 and £2 a gramme.



Is eating genetically modified potatoes going to harm my health?

Here's the story on potatoes. Back around the middle of the 19th century, a terrible disease called 'late blight' attacked potatoes in Ireland. The leaves turned black and withered. A few days after the potatoes were dug up, they turned into a blackish, slimy, rotting mass. More than a million people died, and another two million left Ireland.

The disease is caused by *Phytophthora infestans*, a fungus-like microorganism called an oomycete. The disease is still with us, decimating as much as 20 per cent of the 320-million-tonne global potato crop. Traditional plant breeding doesn't work very well for resistance, not because the disease resistance genes are bad, but because all kinds of genetic baggage goes along with them – tens of thousands of genes. So instead, potatoes are doused with fungicides. Growing potatoes are sprayed as many as 10-15 times in the UK. Fungicides are toxic chemicals, some worse than others. The copper fungicides used by organic farmers (yes, organic farmers use pesticides) are a special problem. They're poisonous for people and animals. Worse, using them means copper-resistant bacteria thrive at the expense of others, and such copper-resistant microbes are often also resistant to antibiotics.

So what if I told you I know which genes wild potatoes use to resist this terrible disease, and that I could pick out just a few of those genes from a wild potato you wouldn't want to eat and add them to your favourite tasty potato? No genetic baggage comes along, just the right resistance genes. It's still your favourite potato.

That's exactly what scientists in the UK have been doing – carrying out research trials of GM potatoes in Norfolk. Germany's BASF Plant Science is going a step further – it is looking for European Commission approval of its new blight-resistant GM potato, Fortuna. Scientists at the Sainsbury Laboratory, Wageningen University and BASF have used knowledge – decades of studying natural disease resistance – and biology to develop potato plants that can shrug off the 'devastating plant destroyer'. If approved,



"Using genes to improve and protect crops is better than using chemicals"

Fortuna could be grown and sold across Europe, including Britain, by 2014 or 2015.

Are the added genes harmful? No, they're just bits of DNA, the same as the rest in the potato. Are the proteins they code for harmful? No, they're tiny variations on the resistance proteins the potatoes already make, but which have stopped being effective. Can adding genes this way create unexpected problems? A recent EU report draws on 25 years of biosafety research on genetically modified organisms (GMOs) to conclude that GM methods of crop modification are no more likely to cause problems than traditional methods. But will you get to eat those tasty, healthy potatoes untouched by fungicides? I don't know.

They're GMOs, after all. Greenpeace, the Soil Association and the like have given GMOs a bad name. There are many fearsome claims out there about the damage that GMOs cause – although not one of the claims has stood up to hard scientific scrutiny.

The bottom line is that using genes to improve and protect crops, both potatoes and many others, is better than using chemicals. It's better for us, better for the land and better for all of the many creatures with whom we share our precious planet. So why are we so willing to be frightened by nonsense and so reluctant to be persuaded, even by mountains of evidence?

WHAT DO YOU THINK?

Should genetically modified foods be available to buy in the UK?

post@sciencefocus.com



The Analyst Robert Matthews

We can perform gene therapy on ourselves, just by eating an apple or two

The start of a new year is the perfect time to turn over a new leaf. And for me that means no longer howling with derision whenever I hear news that scientists have found a gene “for” some medical condition.

I first acquired this habit over 20 years ago, when scientists were telling us how the Human Genome Project was going to reveal the genetic secrets of a host of diseases like cancer. The implication was that there would soon be new therapies that would see off these diseases forever. Even at the time this seemed unlikely, as genes aren’t that prescriptive. If one identical twin gets cancer, the input from genes is so convoluted and indirect that the other twin faces no more risk than someone unrelated, despite having the same genes.

Then there was the hype about how doctors would treat patients by giving them fresh copies of defective genes, like mechanics replacing dodgy spark plugs. Not surprisingly, such gene therapy has proved a tad trickier, and to this day it has yet to cure anyone of a common genetic disorder. None of this has cured researchers of the desire to trumpet every new genetic link as if a wonder cure were just round the corner.

But now the sci-fi stuff is giving way to something far more remarkable: evidence that we can alter the action of these disease-linked genes ourselves. This idea of ‘DIY gene therapy’ to reduce our risk of lethal disease is based on an often misunderstood fact about genes. We’ve been led to think of them as molecular dictators, determining

“Certain foods really can protect us against killer diseases, by affecting those genes linked to them”

precisely what happens in our cells. But the biggest insight to emerge from the Human Genome Project is that it’s all more subtle than that. The same gene can behave in radically different ways, depending on how it interacts with other genes. And there are other influences too – including the chemicals entering our cells from our diet. Suddenly all that talk about eating a healthy diet seems less like nanny state finger-wagging and more like hard, cutting-edge science. It suggests that certain foods really can protect us against killer diseases, by affecting those genes linked to them.

The evidence comes from a study by an international team led by researchers at McGill and McMaster universities in Canada. They compared the diets of over 27,000 people whose DNA has been analysed for the presence of a genetic quirk codenamed the 9p21 variant. In 2007, a team of gene-hunters found that people with this quirk face a significantly higher heart attack risk. Bizarrely, however, 9p21 has no obvious involvement in the functioning of the heart. Clearly – as is often the case with genes “for” common diseases – the link with heart disease cannot be straightforward. But a big clue has now emerged from the diet study.

This revealed that the quirk is most likely to lead to a heart attack if those possessing it ate a diet lacking in fresh fruit and raw vegetables. In other words, by boosting the amount of salad and fruit they eat, those with the 9p21 variant can dodge its worst effects. Exactly how isn’t yet clear, but the great thing is you don’t need genetic screening or gene therapy. You just need to improve your diet a bit.

The only downside is me no longer being able to laugh derisively at gene-hunters and their “breakthroughs”.



MEET THE COLUMNISTS

The Insider Henry Gee

A senior editor of the respected science journal *Nature*, Henry is the author of several books, including *The Science of Middle Earth*.

The Eco-sceptic Tom Heap

Tom is an expert on all things green. He presents *Panorama* on BBC One and *Costing the Earth* on Radio 4, which questions accepted truths on green issues.

The Analyst Robert Matthews

After studying physics at Oxford University, Robert became a science writer. He is a visiting reader in science at Aston University.

The Medic Michael Mosley

After training as a doctor, Michael joined the BBC to become a presenter, writer and producer. He's *The One Show's* science man and presented *The Story of Science*.



The Insider Henry Gee

High-profile cases of scientific fraud hide a more common problem

The business of science is to venture into the parts of the intellectual map that say, "Here be dragons".

When scientists do experiments, they often do not know what they will find. Sometimes their results will underline what is already known. Occasionally, the results will pull up something that makes headlines. What's less often mentioned is that some of that science turns out to have been wrong. No shame in that – after all, science is all about changing the way we think about the way the world works. Truth is a moving target.

But if you want to attract attention as a scientist, what's to stop you avoiding all those tedious, expensive and messy experiments and just making stuff up? After all, who's going to find out? There you are, doing research that's groundbreaking by definition, so who's going to know if the results you get are real or invented? And if you want to finish a piece of work and publish it in a high-impact scientific journal, ensuring that you get job security or that next vital grant, who's going to notice if you fudge a few data points to get the results the way you want them?

Given that cases of outright scientific fraud still have the capacity to astonish, this kind of behaviour is not as prevalent as you might think. The punishments, if you get caught, are severe. Perhaps the biggest case in recent years was that of German physicist Jan Hendrik Schön, who published a string of high-profile papers on semiconductors in top journals

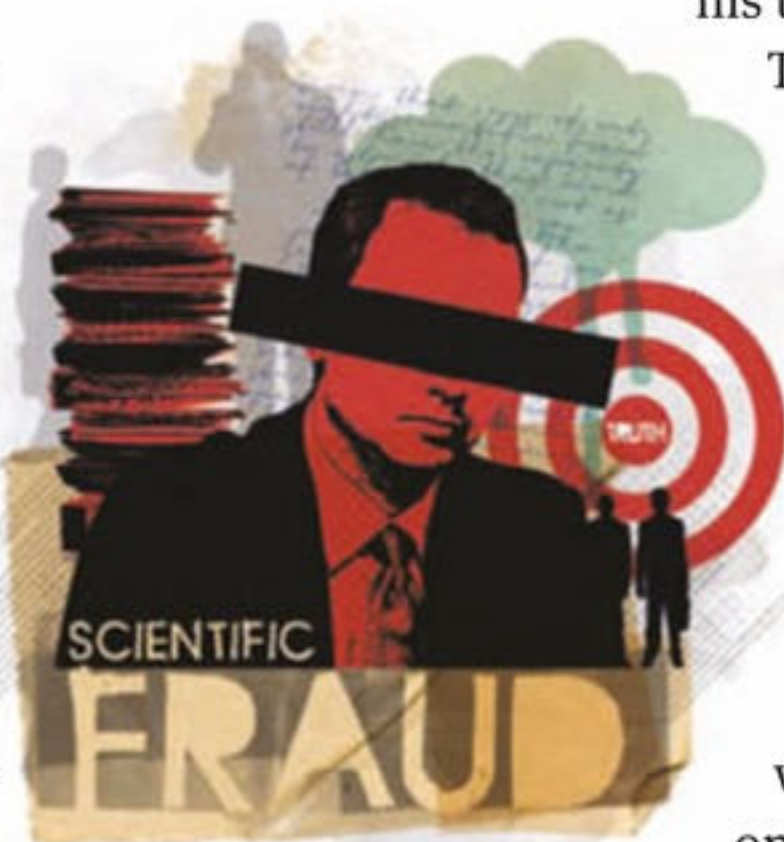
such as *Nature* and *Science*. When scientists couldn't reproduce the results, questions were asked about Schön's work, eventually exposing fraud on a huge scale. Twenty-nine scientific papers co-authored by Schön were retracted, and questions remain over a clutch of others. The University of Konstanz also revoked Schön's doctorate degree.

The latest case in the news is that of Dutch psychologist Diederik Stapel – responsible for studies on subjects such as discrimination and the effectiveness of advertising. An interim report by

his university, the University of Tilburg, has concluded that dozens of his papers – it hasn't specified which – contain fabricated data. It's thought his co-authors were unaware of what was going on.

Such high-profile cases are rare, but worrying in that they might hide a more widespread problem – albeit one that's less severe. Every researcher, if they are honest, will admit that they sometimes ignore or play down results that go against their ideas of what the answer 'should' be. When you're working under pressure, such biases can creep in very easily.

In the great scheme of things, the truth will out. In the meantime, we journal editors have been trained to look at certain kinds of data very, very carefully. Only once in my career as a scientific editor have I stopped a paper before publication because of fraud, and that's only thanks to the sharp eyes of a copy editor who spotted an anomaly just as the paper was going to press. Sorry, my lips are sealed. It's for your own good – if I told you any more, I'd have to kill you.



The Medic Michael Mosley

Hypothermia can be a life saver

One of the few things I fight with my wife over is the thermostat. She turns it up, I turn it down. I tell her it's slimming (shivering burns a lot of calories), but she's not buying it. Where we do agree is that cold has remarkable therapeutic value. Years ago I made a film with a soldier from the Falklands War who, despite staying out on a cold hillside with a severely injured leg overnight, had not only survived but made a terrific recovery. I've been interested in the power of cold ever since.

I've seen it used in operating theatres to buy the surgeon time to operate on someone's heart, but recently I saw it used in a far more extreme situation. I was in the department of critical care at the University of Pittsburgh when a casualty was wheeled in. He'd been shot, and he'd lost so much blood his heart had stopped.

The ER team leapt into action, trying everything they knew to get the heart working again. But they got no response. So they pumped the patient's veins full of ice-cold saline solution, enough to induce a state of severe hypothermia. In this death-like state, the brain and other major organs can survive without oxygen far longer than normal.

What I was watching was only a training exercise. But Dr Sam Tisherman and his team were practising with serious intent – they're due to start the first ever human trial of this hypothermia therapy in a matter of weeks. "At normal temperature and with no blood flow for more than five minutes you have a pretty high risk of brain damage," Tisherman explained. "We're hoping that with cooling in a trauma situation we can get up to an hour. That gives us enough time to get to theatre and stop the bleeding."

Dr Tisherman believes any risks are outweighed by the benefits. Is he right? I will keep you posted.

WHAT DO YOU THINK?

Can diet affect our genetic health?
post@sciencefocus.com

Your Letters

Letter of the month



The letter of the month author wins a copy of *Future Babble*

Write in and Win

I think most scientists would be just as happy if the Higgs boson wasn't found, as they could then investigate something new and exciting. If it is found, it confirms the work they've already done. I see it as a win-win for science. – Ed

Life on Mars



I was pleased to see the publicity given to the potential exploration of Mars (p36, November). My own support for a space programme is based, in part, on two quotations. Russian rocket scientist Konstantin Tsiolkovsky: "Earth is the cradle of mankind, but no-one stays in the cradle forever"; and American science-fiction writer Robert A Heinlein: "The Earth is now simply far too small and fragile a basket for the human race to continue to keep all of its eggs in."

The Chinese seem to be moving forward with their own space programme at considerable speed, and there is a revival on the part of the Russians following NASA's removal of the Space Shuttle from service. If you don't keep going forward, you end up going backward – stability can easily turn to stagnation.

Terraforming Mars would be a project far beyond anything mankind has previously attempted, but a second Earth would be a prize beyond calculation.

Peter Davey, Bournemouth

That's a solid argument for continuing manned space exploration, Peter, although I doubt that even superpowers like China would be able to go it alone these days. Future space exploration is much more likely to be a collaborative and international venture, given the high costs involved. – Ed

Russia is venturing back into space, while other nations are starting to follow



Faster than light?



In the September 2010 issue of *Focus*, you ran a feature called 'How to defy physics'. In the feature was a sidepanel explaining that Einstein's special theory of relativity does not set a maximum speed limit in the Universe, but rather says that it's impossible for objects to cross the light-speed barrier. The sidepanel went on to discuss tachyons, theoretical particles on the other side of the light-speed barrier.

When the neutrinos recently fired from the particle accelerator at CERN to Gran Sasso in Italy apparently travelled faster than the speed of light, your Update story (p22, November 2011) noted that for subatomic particles this speed was "impossible according to Einstein's theory of special relativity".

Is Einstein's theory open to interpretation, or are physicists split into two camps regarding tachyons?

Michael Earley, Germany

Robert Matthews replies: *When it comes to tachyons I'd argue that there is something of a split.*

George Sudarshan, who came up with the tachyon idea, and others think tachyons should be taken seriously. On the other hand, many physicists regard the appearance of tachyons in a theory to be a bad thing.

Hunt for the Higgs



If the Higgs boson isn't found, it presents a problem for science. A lot of scientists have come to accept the 'standard model', and have even founded careers upon it. Those people will most probably be unwilling to re-write science, especially if no

clear successor to the theory can be found.

Some scientists can be guilty of creating a kind of dogma they're unwilling to break, sometimes due to personal reasons such as money, or sometimes due to human nature. People in general don't like having to reject an entire system of thought they know, and be thrust

into the unknown, unless it's by their own design.

I personally don't think that they will find the Higgs boson. If all ends in failure, however, the people who've worked so hard to find out should not be forgotten, as science is built not just on discoveries, but also the absence of them.

Nicholas Riding, Poulton le Fylde

WHAT DO YOU THINK?

post@sciencefocus.com

Focus magazine,
Tower House, Fairfax Street,
Bristol, BS1 3BN

We assume that all views submitted are for publication unless otherwise stated. We reserve the right to edit correspondence for clarity and brevity. We regret we can't reply to all the letters, emails and posts we receive.

Wind power: a work in progress and forever at the mercy of the weather



Where's the wind?



Robert Matthews says wind speeds are falling (p27, November). In the 1980s, the now late Prof JA Taylor of the Geography Department, Aberystwyth, said that the last 25 years of every century were the windiest and the first 25 years had the lowest wind speeds. He based his arguments on historical records.

Evan Lynn

Robert Matthews replies: Since even vaguely reliable records have

only been around since the 1950s, this evidence seems to consist of precisely two data points!

Salt: sea vs table



In November's Quickfire Q&A (p81), Luis Villazon

says he's not aware of any peer-reviewed studies that show sea salt is healthier than pure sodium chloride. But table salt nowadays isn't pure sodium chloride, it's more like 97.5 per cent – the rest being some pretty scary additives.

It's possible to buy table salt that is effectively dried sea water. This salt is only 84 per cent sodium chloride, the rest of it being 14 per cent sulphur, magnesium, calcium and potassium, and 2 per cent trace elements – hardly "negligible concentrations", as Luis puts it. It's more expensive but arguably much less toxic.

Henry Chance, Ludlow

Luis Villazon replies: Food additives all have to be tested for any negative effect on our health before they're approved and are used in carefully prescribed concentrations. That isn't true of a natural product like sea salt. There isn't any evidence of a tangible health benefit one way or the other, so the implication that by being natural it is automatically better for you doesn't really hold.

Oops... On p17 of November's issue, we said NASA's Space Launch System would weigh the equivalent of 29 fully loaded 747 jets. It will actually weigh the equivalent of seven fully loaded 747s.

THE BIG DEBATE

have your say at sciencefocus.com/forum

Was Mars500 (the simulated interplanetary mission) worthwhile?

Absolutely. For prolonged space missions we need to know how professional people with a sense of commitment and risk awareness will fare. Space travel will be risky enough without worrying about an individual becoming paranoid and finding ways to lure fellow crew members into a booby-trapped airlock.

M Paul Lloyd

I'm not sure – there was a complete lack of potential peril: they could exit via the door with only their contracts to worry about later. The endeavour lacked the mitigating factor of

being an explorer at the cutting edge of exploration. Actual, prolonged isolation in an extremely hostile environment, but with an incredible payoff, are dynamics that can't be reproduced, at least ethically. The test will be in the doing.

Shadowwolf

About the nearest we can get to an actual mission is what Dr Alex Kumar is doing. Funded by the European Space Agency, he's going to Concordia base in Antarctica to study the effects of low pressure for long periods on the human body. Due to its

altitude and weather, the pressure is similar to proposed Mars spacecraft pressures. With limited communications and no broadband, there's real isolation.

Graham Ogle

Worthwhile? Affirmative! This mission is not a one-off. I expect several more missions of shorter durations will be conducted. There's already a wealth of information available from the 2010 Chilean trapped miners, and there was also the Antarctic substation female scientist who was trapped.

KingPhillip

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Acting Art Editor Steve Sayers
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Picture Editor James Cutmore

CONTRIBUTORS

Charles Arthur, Susan Blackmore, David Bodycombe, Jo Carlowe, Heather Couper, Gwynne Dixon, Jane Douglas, Tim Durant, Joe Eden, Nina Fredoroff, Will Gater, Henry Gee, John Gribbin, Alastair Gunn, Timandra Harkness, Nigel Henbest, Jamie Hetherington, Spencer Kelly, Ger Leblaque, M Paul Lloyd, Peter Lunn, Gareth Mitchell, Michael Mosley, Jheni Osman, Press Assoc., Hamish Pritchard, Bill Thompson, Luis Villazon, James Witts

ADVERTISING & MARKETING

Advertising Director Caroline Herbert
Advertising Manager Amie Price-Bates
Senior Brand Sales Exec Iain Bryan
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Newstrade Manager Rob Brock
Head of Subscriptions Marie Davies
Marketing Coordinator Mark Summerton

INSERTS

Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION

Joanna Marshall +44 (0)20 433 2183

PUBLICITY

Press Officer Carolyn Wray

PRODUCTION

Production Director Sarah Powell
Production Coordinator Pip Smith
Ads services manager Mel Watkins
Ad coordinator Fred Bennett
Ad designer Steve Boswell

PUBLISHING

Publisher Andrew Davies
Chairman Stephen Alexander
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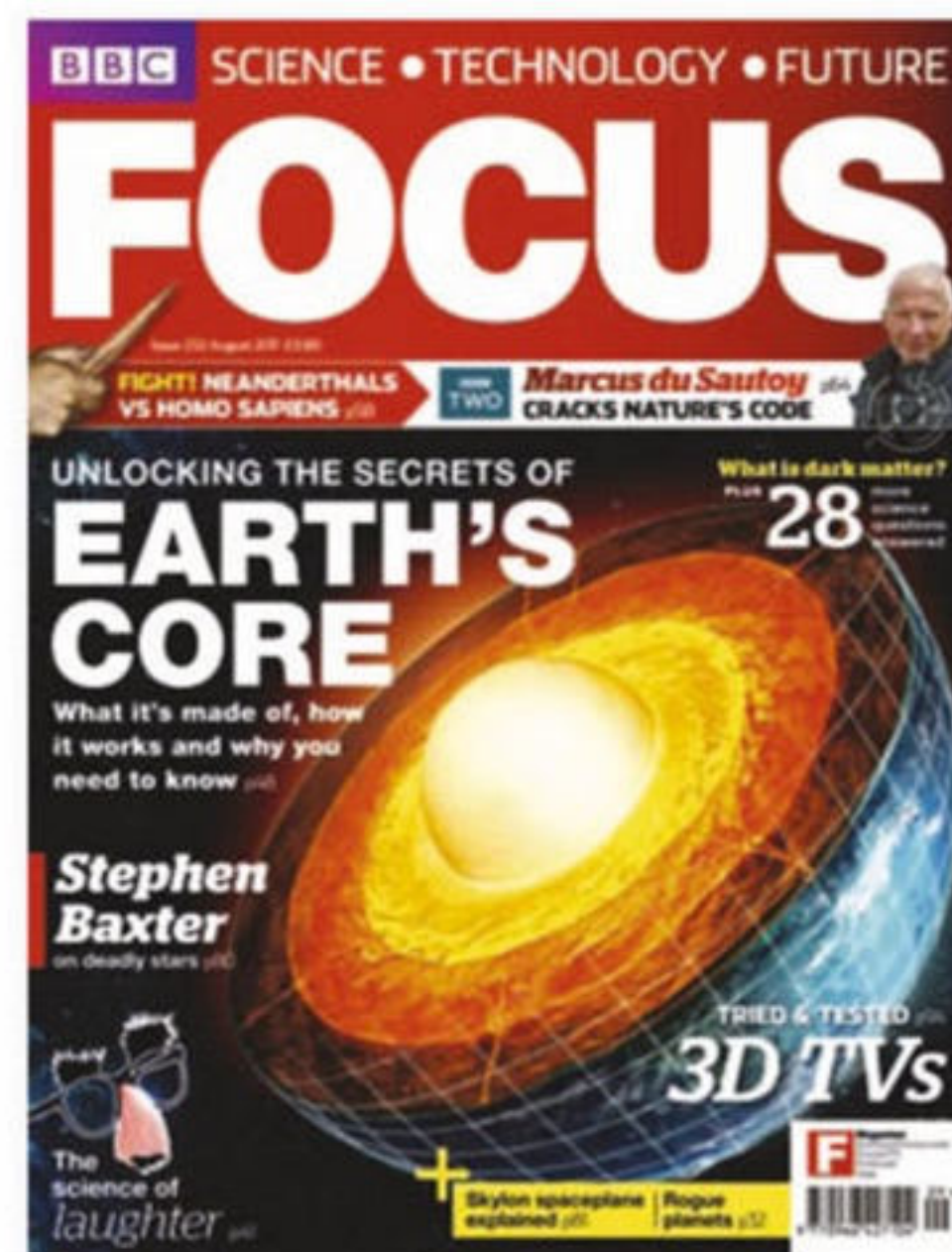
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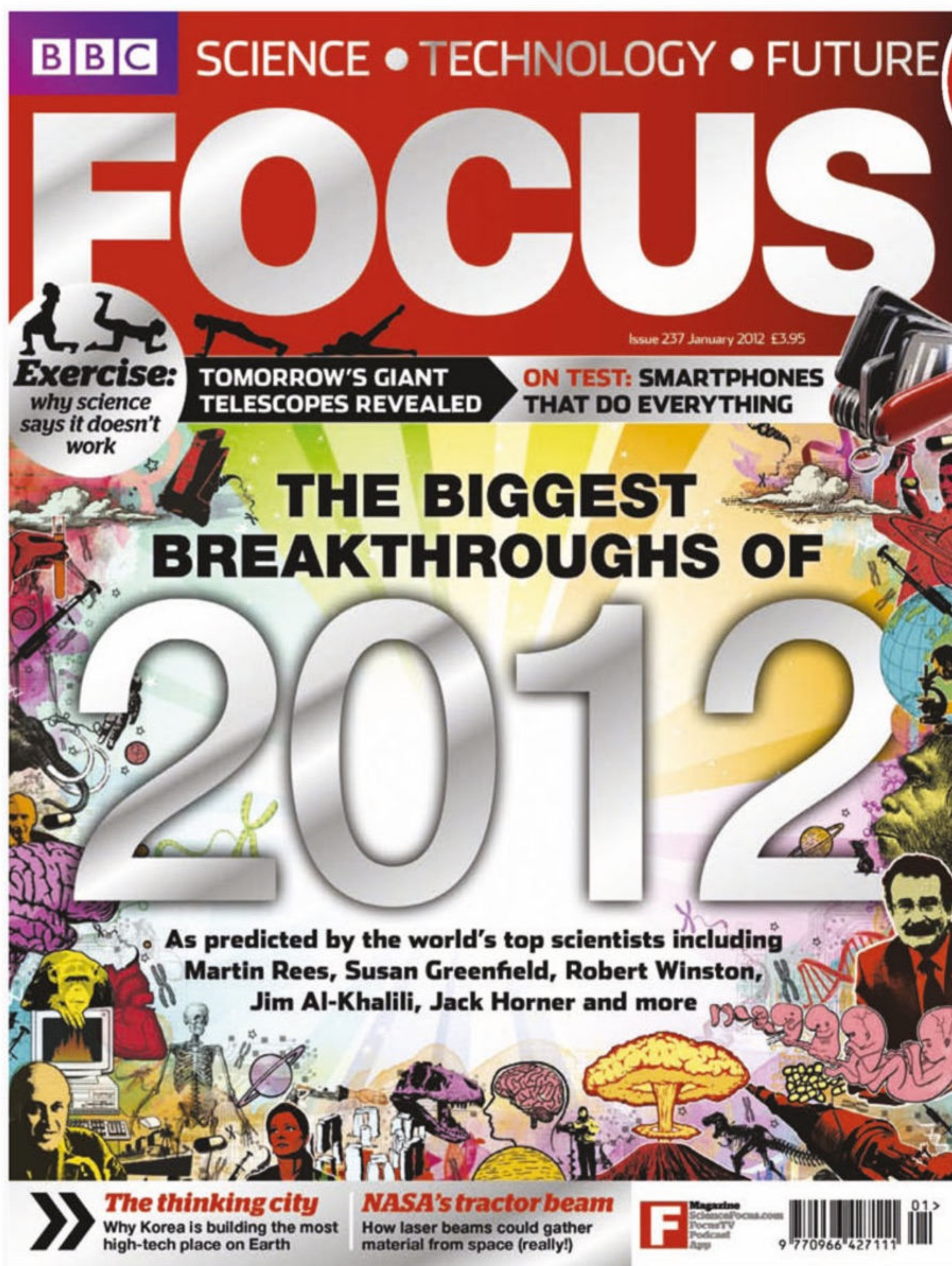
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"MP3 player or a Brennan? I'll have both thanks" says Jools Holland



In a recent interview Jools reveals that, even though he owns an MP3 player, the ability of the Brennan JB7 to store, browse and play up to 5000 CDs* at the touch of a button, as well as record from CD,

tape or vinyl at the very highest quality, makes it the perfect machine for his precious and unique music collection.

Since getting my Brennan, some people have asked me why I don't just have an MP3 player. Well I do, but I've got bucket loads of CD's, yards of tapes and records and I wanted to record and listen to them at the highest quality. If you transfer something from one medium to another and then record it on to a CD, you don't want to then degrade it again when you store it.

"Digital break up is as irritating as dandruff"

An MP3 player typically records at 128 kilobits, whereas the Brennan starts at 192, goes up to 320 and then beyond that you can record uncompressed.

My MP3 player is very handy to take on tour or on holiday, but if I want to archive something important I'll use the Brennan. Downloading from the Internet isn't bad, but for me it's a little time consuming. I always want the easiest and fastest way to do something. If I had to unlock my piano, walk through a few hoops and put a password in before playing, it would be rather long winded and I'm not sure I could be bothered.

"I've got drawers full of cassettes, boxes full of CDs and 28 feet of vinyl records, so I definitely needed a Brennan"

Apart from recording quality, what I was really after from the Brennan was being able to archive a lot of my own music. The Brennan is a great way of distilling it all down to be able to enjoy it.



VOTED 'BEST BUY' BY
GRAMOPHONE MAGAZINE,
WHAT HI-FI & SUNDAY TIMES



"Many of my personal recordings in my collection are old and quite rare"

For example, I made a film about the music of the film and TV composer Edwin Astley. When making it his family sent me some reel-to-reel tapes of his incidental music from films and dramas. It's of its time and very charming. When making the film about him I put all his incidental music on to one CD. It is the sort of thing you couldn't get anywhere. I also have things like a CD of myself and Willie Dixon, the greatest blues composer of all time, in New York together in the 1980's. The other day somebody sent me a CD of me doing a solo show in Boston in 1981. It's wonderful to have all of these memories on CD, but as we know, they're quite fragile and have a limited life span.

"When CDs came out we all assumed you could use them as a Frisbee, spread jam on them and they would still work perfectly well"

It turned out this was not the case. You might have noticed that some CD's have the habit of not working, particularly the ones that you record yourself. These are exactly the sort of things I'm recording on to the Brennan, not just as a back up but so I can listen to them whenever I want without having to search for them.

I'm not trying to load everything in one go. I'm going to slowly enjoy transferring them piece by piece gradually archiving my collection. I play a lot of blues and roots records. I trawl through a lot of music and I'm constantly at the song face. I'm looking forward to distilling the best of these blues records on to my Brennan. This also includes some 78 recordings I have and enjoy listening to on shellac.

"It's important for me not to forget the music that has touched me over the years"

It doesn't really matter if a piece of music is 5 minutes old or 500 years old. When you hear it if it has the effect of lifting your human spirit then its done its job. My Brennan is enabling me to reconnect with a lot of my old music that did just that.

*In 2006 the record companies said unequivocally that they are happy for you to load your own CDs onto a hard disk but the Advertising Standards Authority have asked us to tell you that it is unlawful to copy material without the permission of the copyright holder.



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As predicted by Martin Rees, Susan Greenfield, Bill McGuire, David Phillips, Jack Horner, Robert Winston, Lisa Randall, Jim Al-Khalili, Chris Stringer, Phil Jones, Brian Fagan and Chris Bishop



ASTROPHYSICS

Martin Rees

Astronomer Royal and Emeritus Professor of Cosmology and Astrophysics at the University of Cambridge

A major advance in 2012 will come with the first results on background radiation in the Universe from the Planck spacecraft, launched by the European Space Agency in 2009. Early data from Planck has mainly been about foreground objects such as clusters of galaxies. The most interesting observations will be of the cosmic microwave background radiation, a relic of the early Universe. Subtracting these foregrounds will reveal the background fluctuations that are the seeds of cosmic structures.

The early Universe wasn't completely smooth – if it had been it would still be cold hydrogen. We see today galaxies and clusters of galaxies that arose from small fluctuations in the early Universe and grew under gravity. The greatest achievement in the last 10 years has been to show that fluctuations in the microwave background have the right properties to give rise to the structures we see today.

A second breakthrough will be to discover a distant object with a red shift greater than 10, which would mean we were seeing back in time

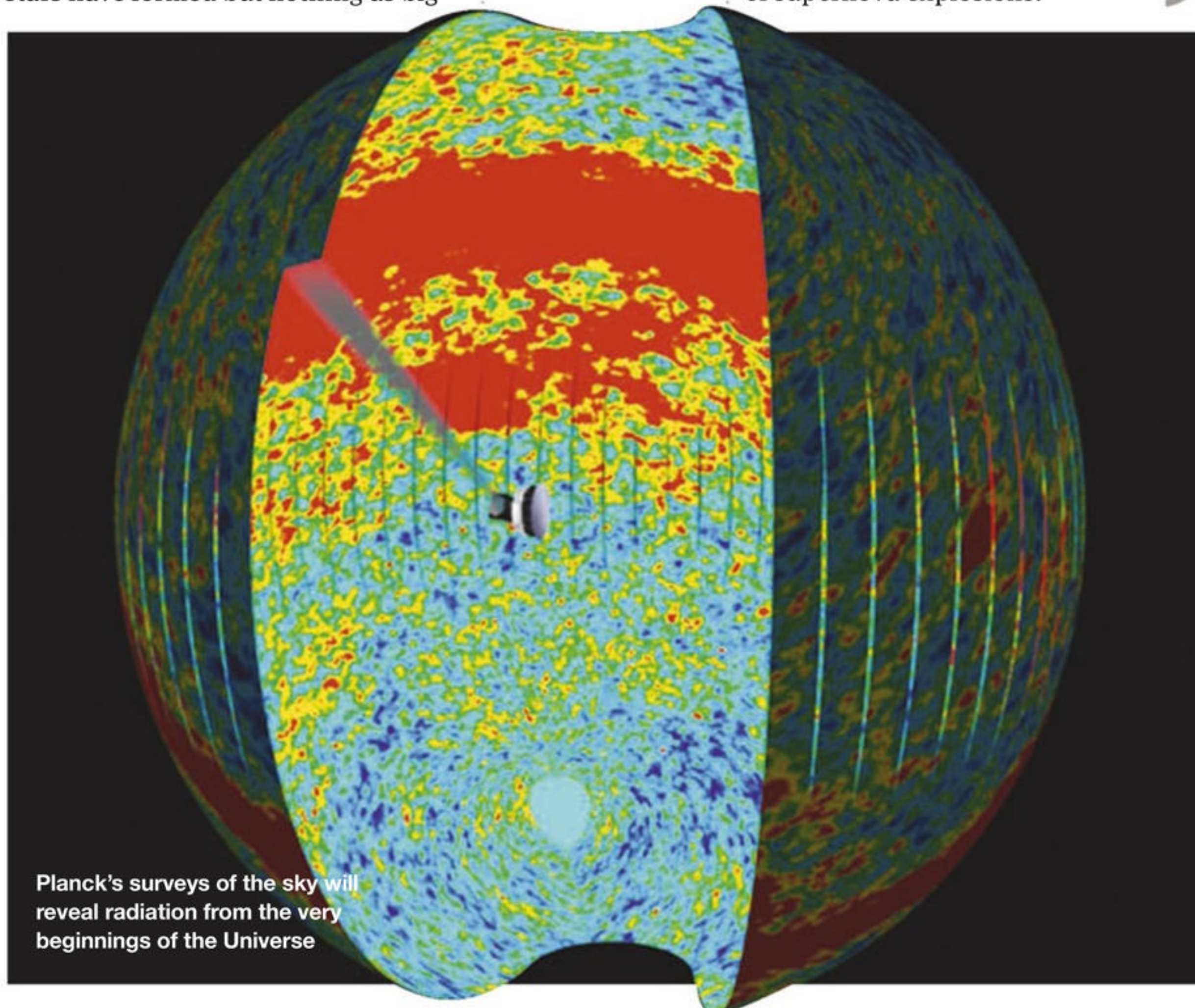
to the very early Universe. We have already had a gamma-ray burst (GRB) – an explosion caused either by two neutron stars merging or by a peculiar kind of supernova – with a red shift greater than eight.

There have also been tentative claims of even more distant objects, revealed after a closer cluster of galaxies magnified them by acting as a gravitational lens. To find an object with a red shift greater than 10 will help us understand the pre-galactic stage of the Universe, where maybe stars have formed but nothing as big

“Comparing a virtual Universe with the real one will allow us to understand how galaxies form”

as a Galaxy has assembled. NASA's Swift satellite, which spots GRBs, should be able to detect higher red shifts if they're bright enough.

The third major advance will be in simulations as computing power improves. A lot of our understanding of how galaxies form, and dark matter behaves within them, comes from elaborate simulations of galaxy collisions. Comparing a virtual universe with the real one will allow us to understand how galaxies form and do more realistic calculations of supernova explosions.



Planck's surveys of the sky will reveal radiation from the very beginnings of the Universe

Rees's best of 2011

- NASA's Kepler Space Telescope discovered a star system with six or seven planets, and another with a planet orbiting a double star.
- A new type of cosmic explosion was detected, which is believed to be a star being torn apart by the black hole at the centre of the Galaxy.



NEUROSCIENCE

Susan Greenfield

Professor of Synaptic Pharmacology at the University of Oxford

“Perhaps the biggest breakthrough might be the increasing interface of technology with the brain – ‘nanotechnology interfacing’ – the sort of work that Miguel Nicolelis at Duke University does in associating a thought with an action. I think that will be very exciting and very promising as we learn more.

Over several years Nicolelis has managed to analyse the electronic signature in quadriplegic patients and

store it in a computer so that when the person thinks about moving, it activates a prosthetic arm. It means the person can will themselves to move. Nicolelis can send [instructions] across to Japan and make monkeys move and so on. It’s very exciting because it’s looking at the difference between a thought and a movement, and how you translate one into the other. I think the big breakthrough for the future could come from this work on interfacing.”



A brain interface in Nicolelis's lab gives a rhesus monkey control of an avatar's arms



EARTH SCIENCE

Bill McGuire

Director of the Benfield UCL Hazard Research Centre and researcher in volcanism

“We’ll understand a lot more about the feasibility of geoengineering as a means of bringing global warming under control by the end of next year. That’s because a technical study into the idea of floating huge balloons in the stratosphere, from which solar radiation-reflecting particles are released, will take place [As reported in November’s *Focus*].

In the study, a tethered balloon will float 1km above Earth so the particle-release system can be tested before doing it on a much bigger scale. Bristol and Cambridge universities planned to release the balloon in 2011 but it was put back so that discussions could take place with the project’s critics. We’re at the stage where we’ve gone beyond geoengineering simply being a talking point.

My other big area of interest is volcanology. Next year, holes are going to be drilled into the heart of Campi Flegrei, a supervolcano near Naples. People are concerned that drilling 4km into a volcano could trigger an eruption, but that’s not going to happen – it’s too tiny an event to do that.

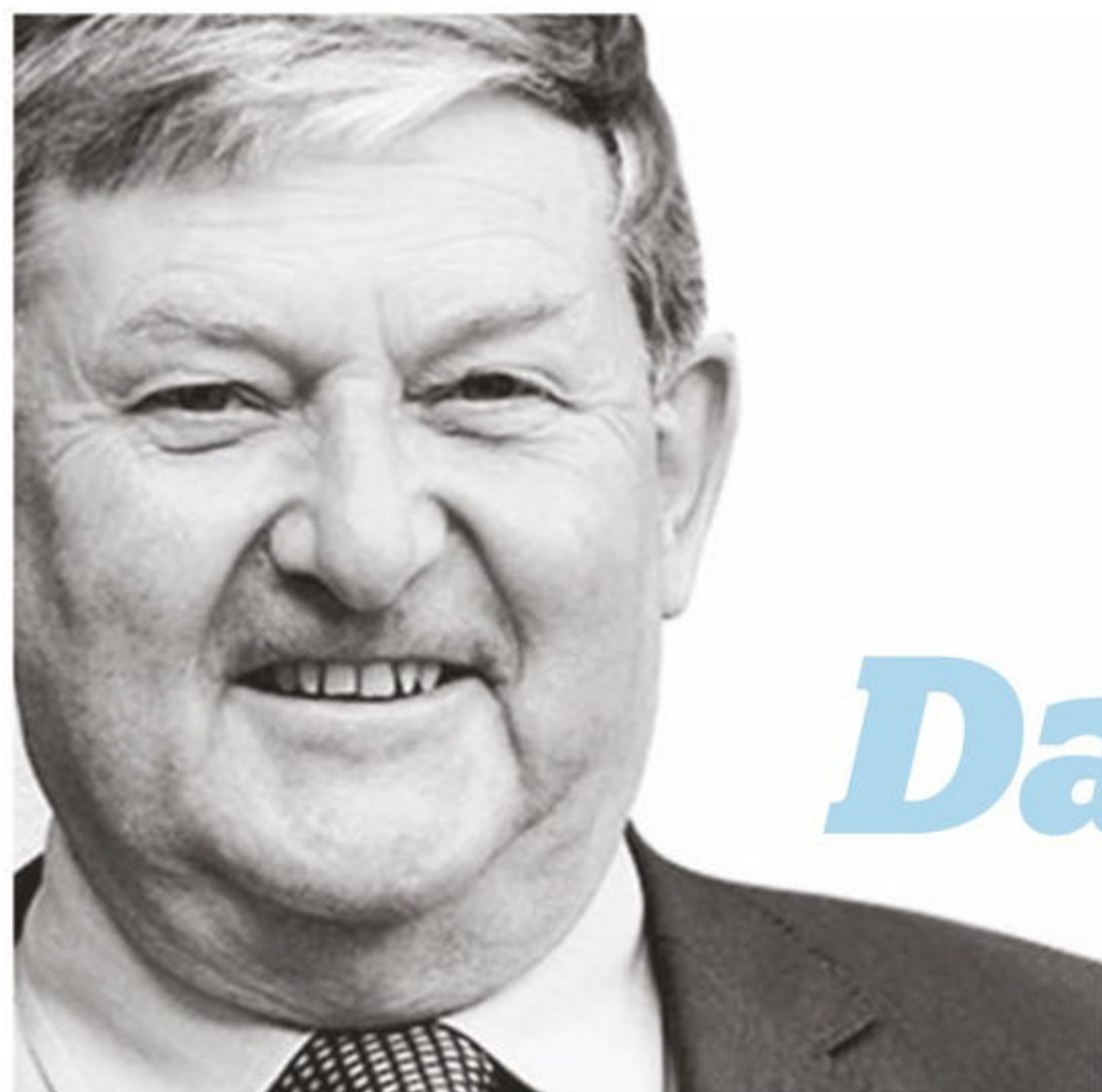
Lots of supervolcanoes are restless, swelling and subsiding, but nobody knows why that happens. It could be new magma coming into the volcano, which has the potential to erupt. Or it could just be magma deep down heating water, and that water increasing in volume as it gets hotter, causing the swelling. The research at Campi Flegrei would shed light on whether the restlessness is largely magma-related, water-related, or a bit of both.”



Drilling a hole 4km down into Campi Flegrei might provide crucial insights into supervolcanoes

McGuire's best of 2011

- A simulation showed that the melting of an ice sheet in eastern Iceland would trigger more volcanic eruptions.
- A computer model predicted that if greenhouse gas emissions follow a fossil fuel-intensive scenario, global temperature could rise 4°C by the 2060s.



CHEMISTRY *David Phillips*

President of the Royal Society of Chemistry
and Emeritus Professor of Chemistry at
Imperial College London

“What grabs people’s attention is healthcare. We’re on the point of sequencing DNA rapidly and cheaply enough that each individual could have their DNA sequenced as part of a standard health check. The development of new techniques for rapid DNA sequencing will allow doctors to tailor medicine to the individual, such that the GP will only prescribe medicine knowing that it’s likely to be effective.

On a similar tack, there’s the work using a variety of physical techniques to look at what causes protein folding, which relates to neurodegenerative disorders – Alzheimer’s and things like Parkinson’s. With a detailed understanding of the physical chemistry of what caused the protein folding and unfolding, you might be able to develop medicines that would rectify it.

As a society, there’s a desperate need for new antibiotics. Many of the principal targets in the past have been developed for disrupting the cell walls of bacteria or having other

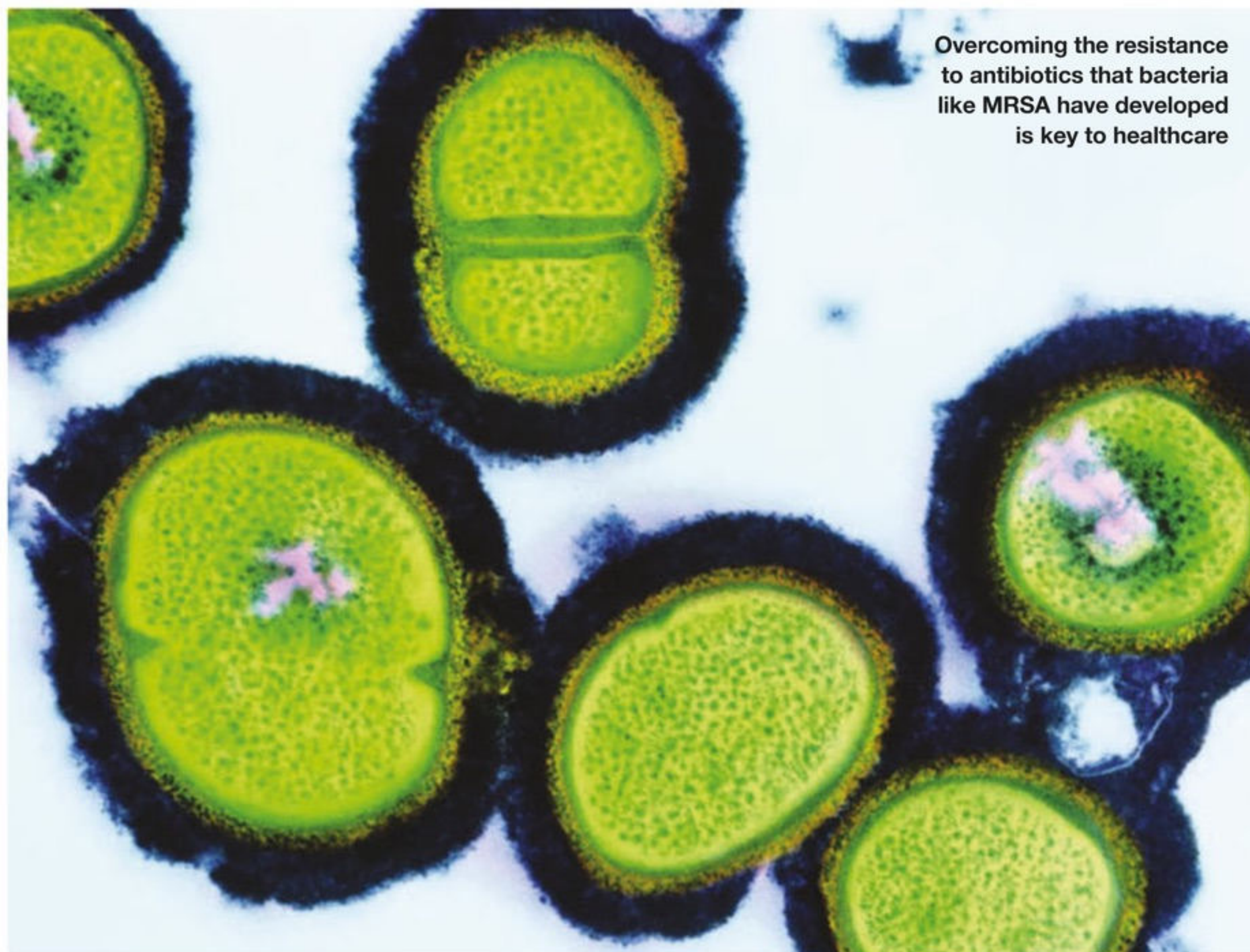
effects, but now we’ve run out of easy targets. Studies are looking for more subtle ways of getting at the bacteria, in understanding different mechanisms for selectively causing their destruction. Selectivity is very important because you want to get at the nasty bacteria without killing the harmless ones, and without building up antibiotic resistance. Indiscriminate use of antibiotics has led us to where we are now.

People have been screening materials from unlikely places, like the soil, to pick up materials that would have an antibiotic effect.

“Studies are looking at more subtle ways of getting at bacteria”

The research is to understand what mechanisms can disrupt the life of the bacterium. So it’s basic biochemical work that will need to produce new materials. Once you’ve identified a target and a molecule that can disrupt or lock on to that target, it can do its damage.

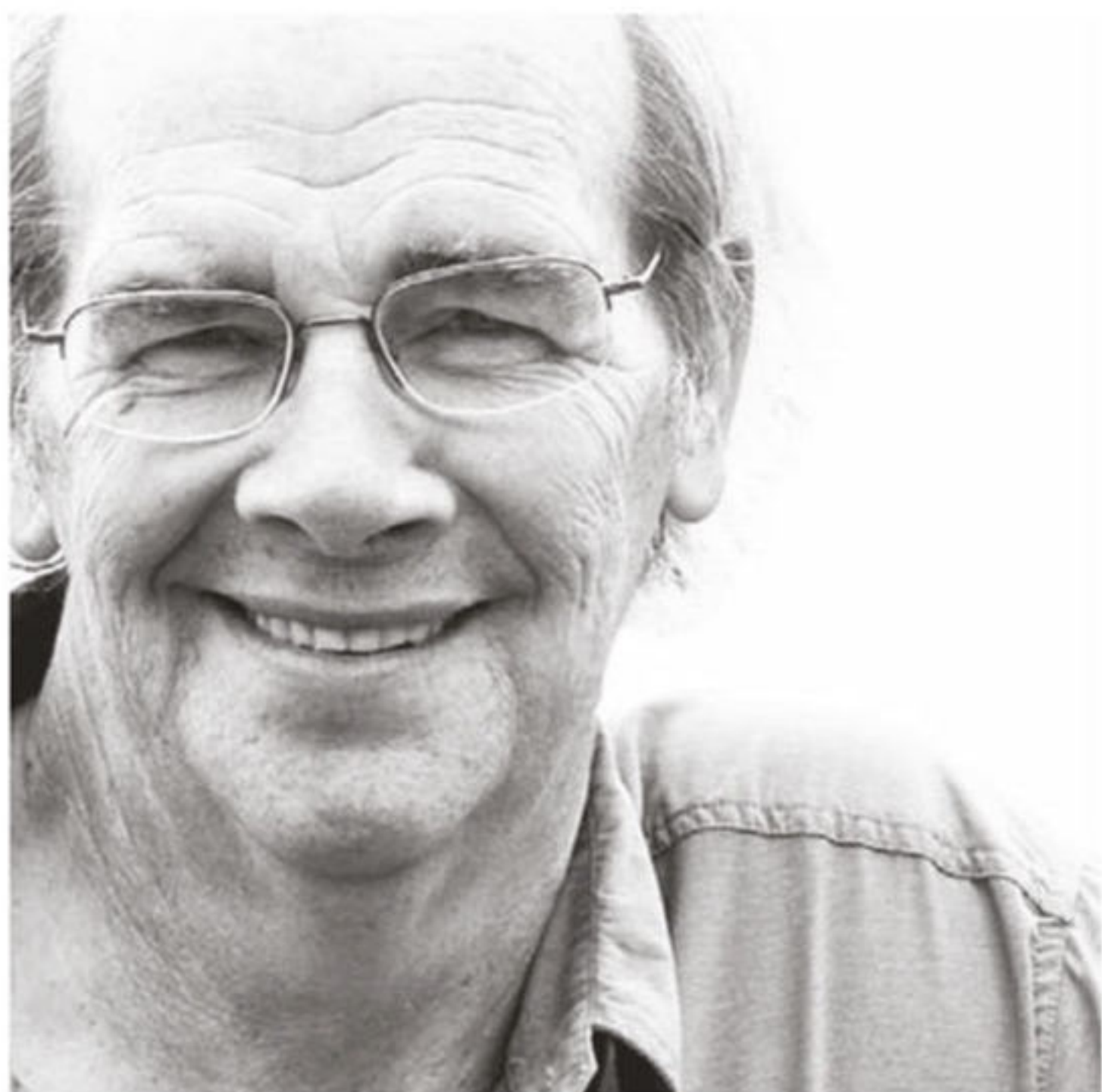
Chemistry will come into its own to manufacture these drugs by all kinds of subtle chemical developments – making new bonds, and new synthetic routes. A different approach to finding out how you can attack the bacterium, which can preferably destroy it selectively – that’s the key. ”



Overcoming the resistance to antibiotics that bacteria like MRSA have developed is key to healthcare

Phillips's best of 2011

- Graphene, a one-atom-thick sheet of carbon, could have a massive impact on electronics.
- Quasi-crystals with five-fold symmetry could be used to create hard-wearing, durable materials.
- Developments in environmental scanning electron microscopy allowed atoms and molecules to be seen in solution, without having to coat the samples with metals.



PALAEONTOLOGY

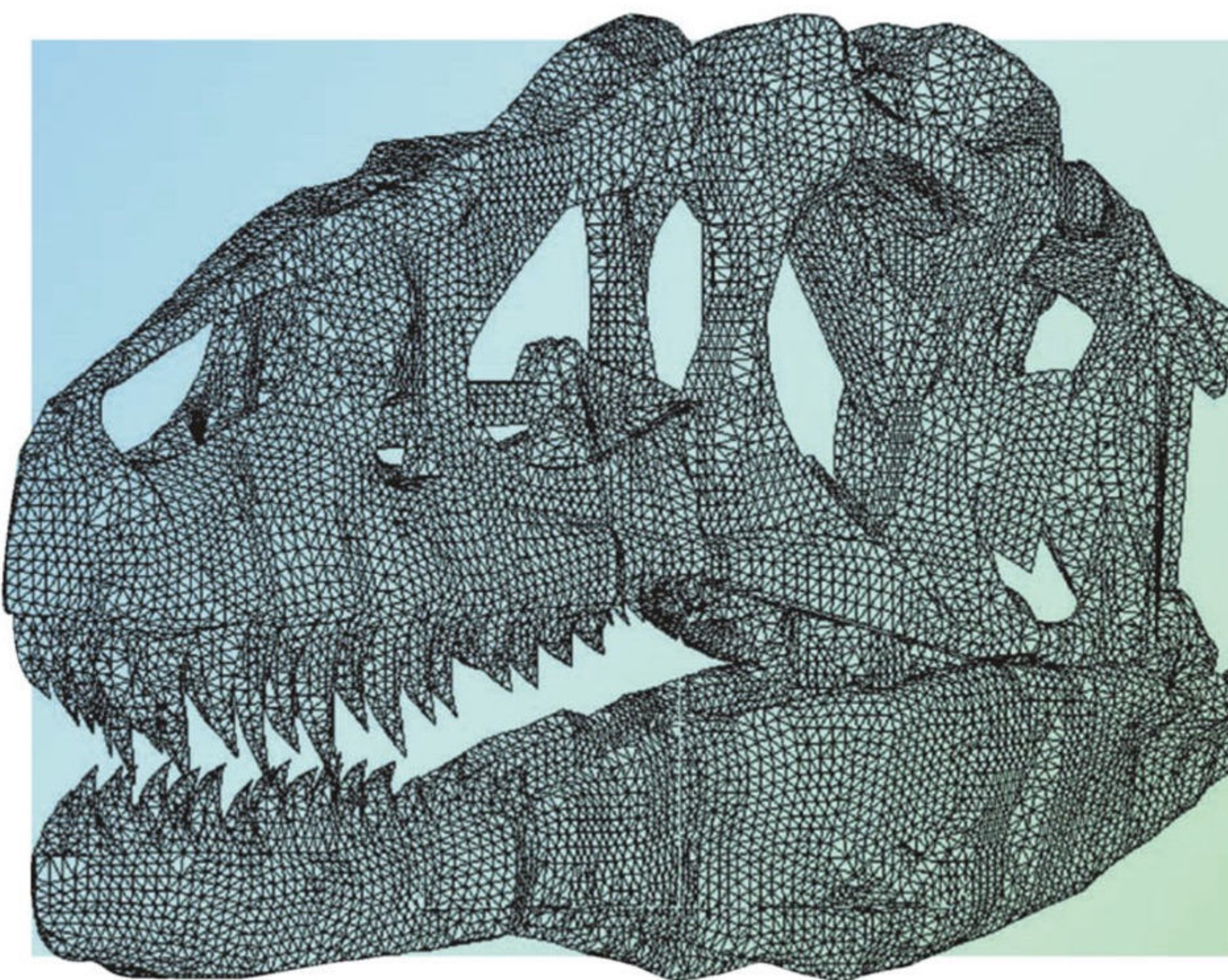
Jack Horner

Regents Professor of Palaeontology at Montana State University and a scientific advisor on the film *Jurassic Park*

“People name too many specimens! What we need is good growth data so we can really start looking at which specimens are juveniles and which are new species. I think there are going to be a lot more statistical and histological [the study of cells] research papers that demonstrate more rigorous science.

I think we're going to see more use of CAT (X-ray) scanners. There are a few CAT scan labs around and they've been producing interesting information, especially the ones at the University of Texas and the Natural History Museum in London. I think we're going to see more and more of the larger institutions do a lot more with CAT scanners because they give us so much information about the function and morphology of these animals. We're definitely going to start seeing a drift away from phylogenetics [study of evolutionary relatedness] and start seeing a move into palaeobiology.

I think the primary focus of biological studies will remain in North America but there's a lot of material coming out of Mongolia. It's one of those places where you can get large specimens of dinosaurs, like Triceratops, Adasaurus and Velociraptor. There are a lot of dinosaurs to be found in Mongolia and my guess is we're going to start seeing some of these large collections used in biological studies. We're mainly looking at the growth, behaviour and physiology of any species we can get lots of, and that's what it requires. For years, people just went out and looked



“Once we figure out Sauropods, we'll have figured out dinosaurs”

for new species. Now we realise that if you can get a lot of specimens of just one species, you can do a tremendous amount of biology with them.

The big questions in palaeontology are the things we haven't figured out how to answer yet, like the colours of dinosaurs or how Sauropods work. We're so mammal-centric, constantly discussing how efficient mammals are. But what we're finding is that Sauropods were definitely not mammal-like and yet they were also very successful. Once we figure out Sauropods, we'll have figured out dinosaurs.”

Horner's best of 2011

- Important finds continued to emerge from China – in particular Liaoning province. Researchers continue to work on specimens found in Liaoning, looking for clues to dinosaurs' colours.
- A species called *Raptorex* was found to be a juvenile and not a new member of the Tyrannosaurid family. The work was carried out by Denver Fowler, Horner's PhD student at Montana State University.



MEDICINE

Robert Winston

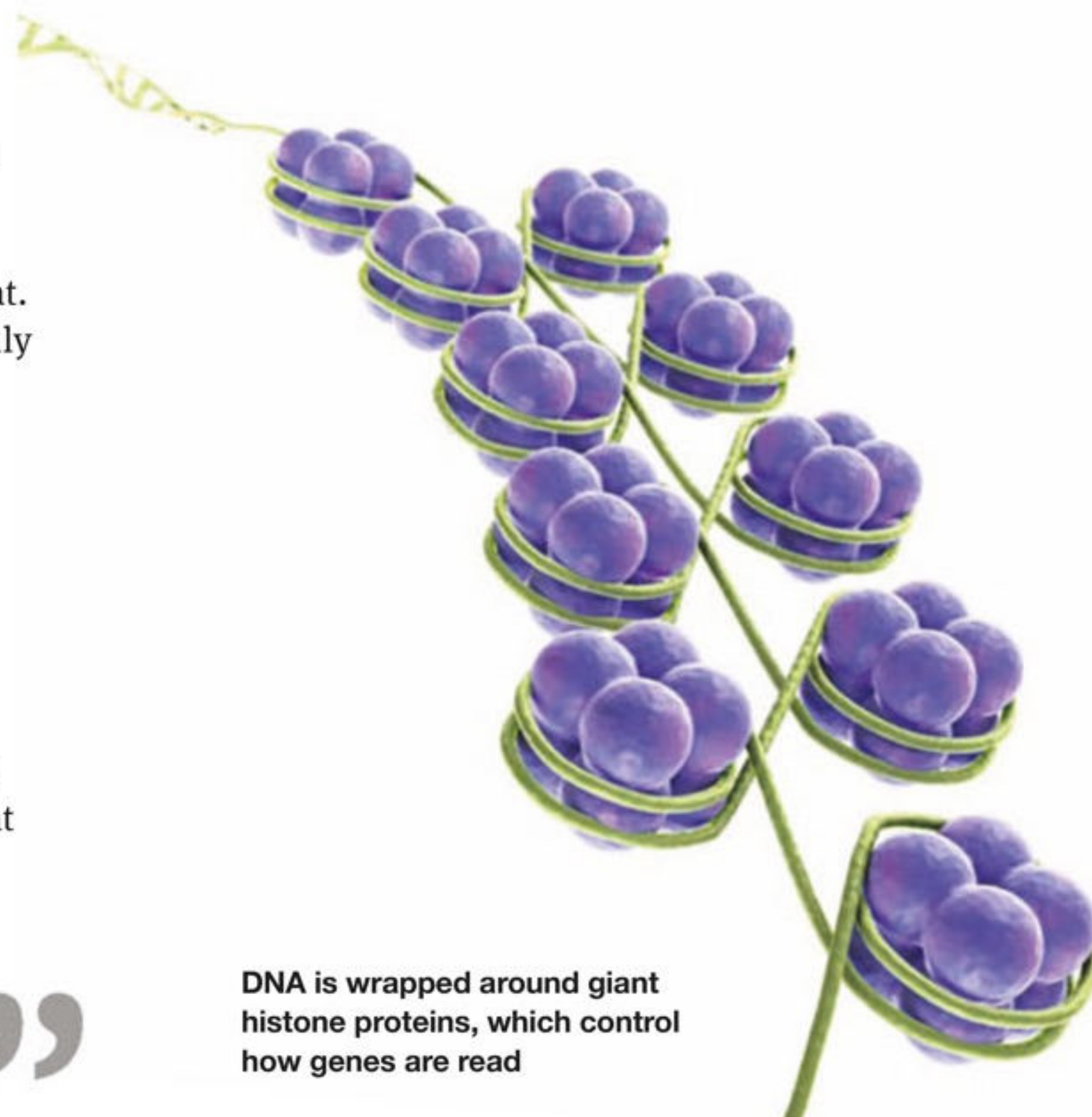
**Emeritus Professor of Fertility Studies
at Imperial College London**

“For medical developments in 2012, I would argue that the most exciting thing is the growing realisation that medical treatments are very ineffective at treating disease. You only have to look at the Commonwealth Fund’s assessment of the British NHS and its assessment of heart disease to see that all treatments are only effective about 30 per cent of the time. Changes in lifestyle are effective 70 per cent of the time. So the question is really: in a world that’s increasingly threatened with economic problems, how do you provide effective healthcare?”

It’s not that I think research into things like the genome, for example, aren’t important. But you might argue that we should reflect on the real risks facing us. One of the biggest of these is lifestyle diseases. By 2020, we’re

going to have around 450 million people in the world suffering from Type 2 diabetes, which affects every organ in the body. In this country diabetes will have doubled and it’s very unclear how we’ll deal with that.

That said, one thing I think is really exciting in science at the moment is the epigenome [the chemical and structural changes to DNA that control how genes are read]. Research that tells us how we can change the way genes function to improve the health of patients will be important in coming years. And with this, the recognition that quite subtle influences in our environment in the uterus, or shortly after birth, may make a massive difference to our physical development and our cognitive development is the start of a revolution in medicine.”



DNA is wrapped around giant histone proteins, which control how genes are read



PHYSICS

Lisa Randall

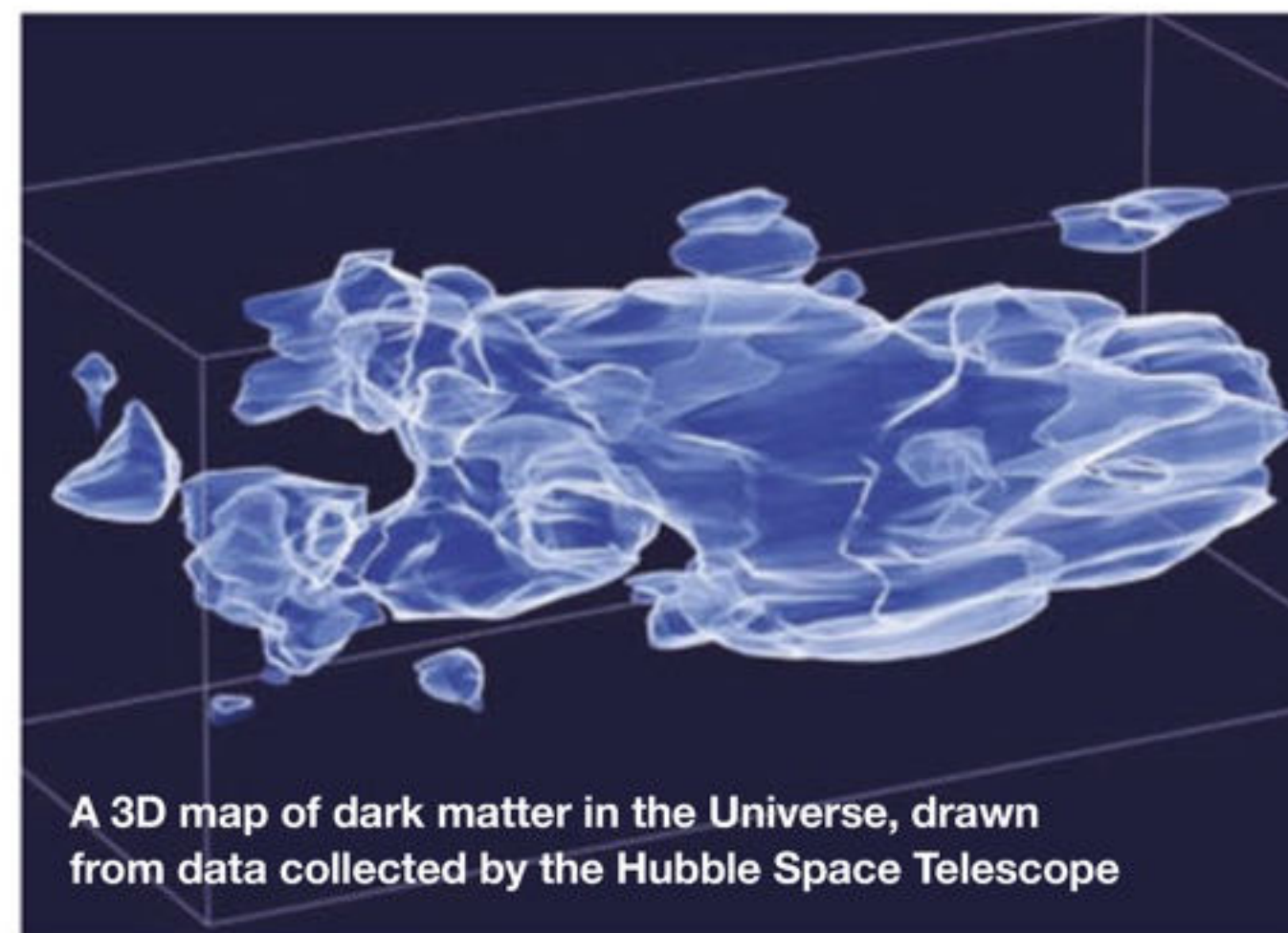
**Professor of Physics at Harvard University and researcher
in theoretical particle physics and cosmology**

“Physicists will say something about the Higgs boson. At the Large Hadron Collider, they’ll have tested the entire energy regime, so whether or not they find it, there will be something interesting there.”

Another interesting measurement has to do with finding dark matter. If the XENON Experiment [deep underground in Gran Sasso National Laboratory, Italy] doesn’t see dark matter, it’s going to constrain a huge class of theoretical models.

In terms of theory, I’m working

on some interesting models to do with combining compositeness [substructure of particles] and supersymmetry [‘partner’ particles that have been predicted] in ways that could accommodate data. I’m also working on ideas that could explain why dark matter density is so close to ordinary matter density. [Dark matter is invisible and only detected through its gravitational interaction with other objects]. I think there will be breakthroughs in understanding the possibilities in both topics.”



A 3D map of dark matter in the Universe, drawn from data collected by the Hubble Space Telescope



PHYSICS

Jim Al-Khalili

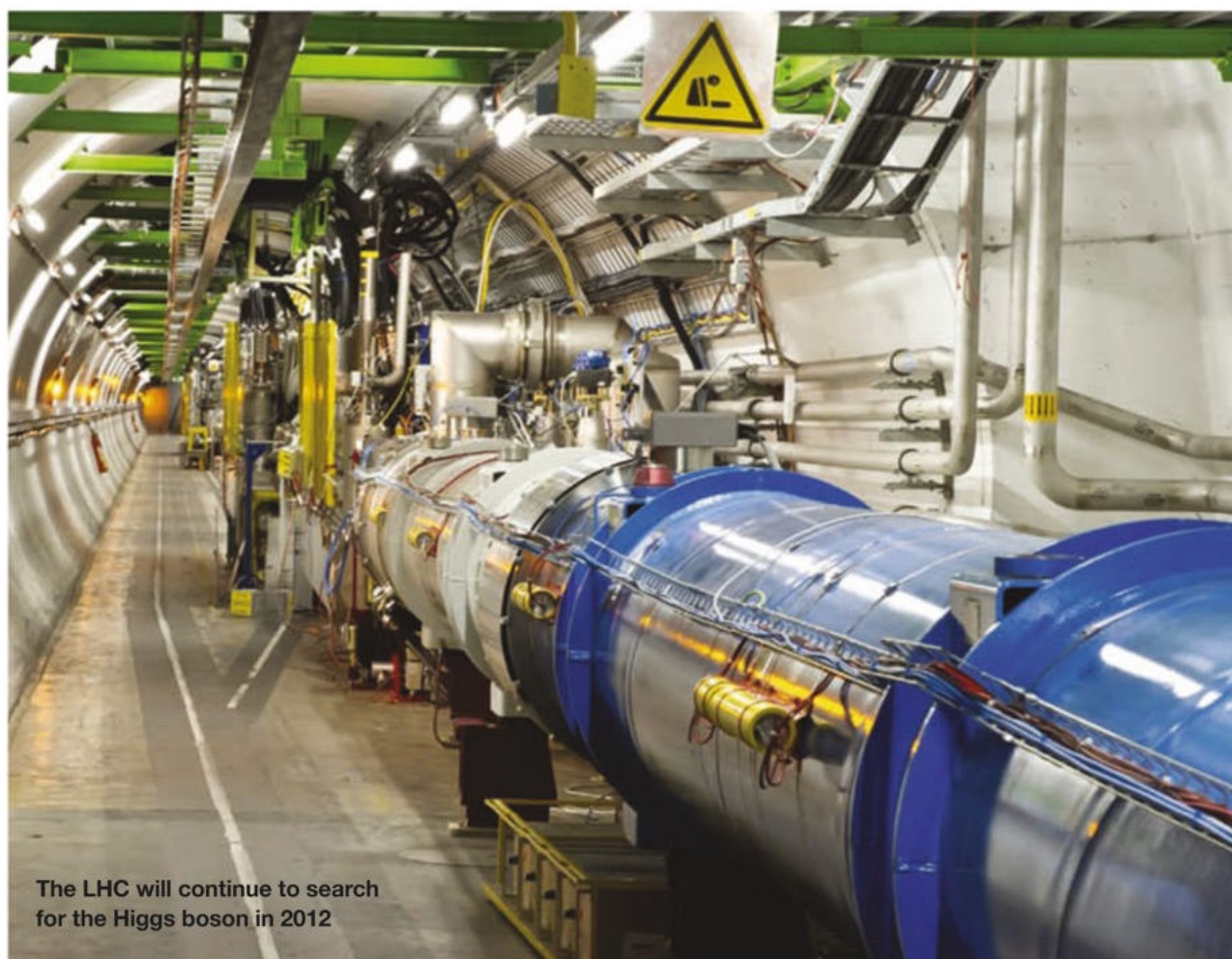
Professor of Physics at the University of Surrey and presenter of *The Story Of Electricity* on BBC One

“For particle physics, next year will be the crunch year for the Large Hadron Collider (LHC) because people are getting twitchy about whether we’ll find the Higgs boson. When they first switched on the LHC, it was like trying to find a particle in a pond. But now they’ve drained the pond and all they’ve got left is a few muddy puddles that it might be hiding in.

In 2012, either the Higgs will be found or they’ll turn around and say: ‘we don’t think it exists’. It would certainly mean an overhaul of our ideas in particle physics. That said, it’s surprising that most physicists have assumed it will be found. There’s been very little debate about what will happen in a Universe where the Higgs doesn’t exist. In all likelihood we’ll just come up with another particle and try and look for that one.

Outside of the Higgs, there’s another group of particles that they’re looking for at the LHC called super-symmetric particles, which are almost like mirror-image particles. In theory, each particle that we know about now should have a super-symmetric partner that’s much heavier. If we can find these particles it would very much help support string theory, which is our current best attempt at an ultimate picture of everything.

Next year we’ll also start to see quantum biology really taking off as a subject. You need quantum mechanics to explain photosynthesis, our sense of smell, bird migrations and all manner of weird things in biology. A microbiologist colleague and I are hoping to arrange an international



The LHC will continue to search for the Higgs boson in 2012

“Next year we’ll also start to see quantum biology really taking off. You need quantum mechanics to explain our sense of smell, bird migrations and all manner of weird things in biology”

workshop in the summer. We want to bring together top people to sum up where we’re at now and where the next discoveries lie.

In America, Paul Davies is working on possible quantum origins to cancer. It’s been known for decades that quantum tunnelling is one of the ways that DNA mutates. Not all mutations can be explained this way but it’s thought some can be. Cancer is ultimately down to cells mutating and then dividing very quickly so it’ll be really exciting to see what developments this new approach will lead to.

Al-Khalili’s best of 2011

- The neutrino story – it was claimed that neutrinos travelled faster than light. One hopes that at some point in 2012 we’ll have an answer.
- The National Ignition Facility in California became the place in the world that will hit the Holy Grail of producing continuous fusion energy.
- Thanks to our study of extrasolar planets, we’re learning that Earth-like planets seem to be quite common.



PALAEONTOLOGY

Chris Stringer

Research Leader in Human Origins at the Natural History Museum and the author of *The Origin Of Our Species*

“We’re going to see the first real discoveries of functional DNA that people outside of Africa received through interbreeding with our ancestors – DNA from Neanderthals and the enigmatic people called Denisovans, from Siberia. Wider comparisons will be made between the genomes of Neanderthals and Denisovans and those of modern humans from around the world, and that will start to show where there are genetic similarities and differences.

We know Neanderthals and modern humans from the fossil record but Denisovans are only known from a few fragments so far. Hopefully more Denisovan fossils will be identified soon. We may also see the first signs from their DNA of how those species were similar to us in terms of how their brains worked, their physiology, their skin colour and perhaps how their skeletons developed and grew compared with our own. So we’re going to get direct evidence of the biology of these other people.

Some of us today – all people outside of Africa – have a percentage of Neanderthal DNA. And there’s a smaller group in Australasia who also have Denisovan DNA. I think we’re going to see what their genes are doing, if anything, in modern humans. It may be that a lot of that DNA is non-functional – it’s just passed through breeding. But I’m sure some DNA is going to be functional – it will be affecting our phenotype [observable characteristics].

Experiments can be conducted on those genes. A gene variant can be put into a mouse, for example, to see what

“We may see the first signs of how species like the Denisovans were similar to us in terms of their physiology, skin colour and the way their skeletons developed”

effect it has on the phenotype. So we’ll see genetically modified mammals in which we can replicate the action of a gene, see what it’s doing and hypothesise its effect in a human that had that same gene.

It sounds like science-fiction but it’s been done already: the FOXP2 gene, sometimes (wrongly) called the ‘language gene’, has been put into mice to see what effect it has on their vocalisations. So that kind of thing can be done now, and I’m sure there will be further publications using these methods in the next year.”

Stringer’s best of 2011

- The discovery of *Australopithecus sediba* suggests the first humans may have evolved in South Africa.
- Uncovering of tools for preparing red ochre pigment provide a snapshot of early modern human behaviour 100,000 years ago.
- The complete DNA sequence of the Aboriginal genome was reconstructed from 100-year-old hair samples from a draw at the University of Cambridge.



Further comparisons between modern man’s DNA and other early hominids, such as Neanderthals (pictured) may reveal similarities



ENVIRONMENT

Phil Jones

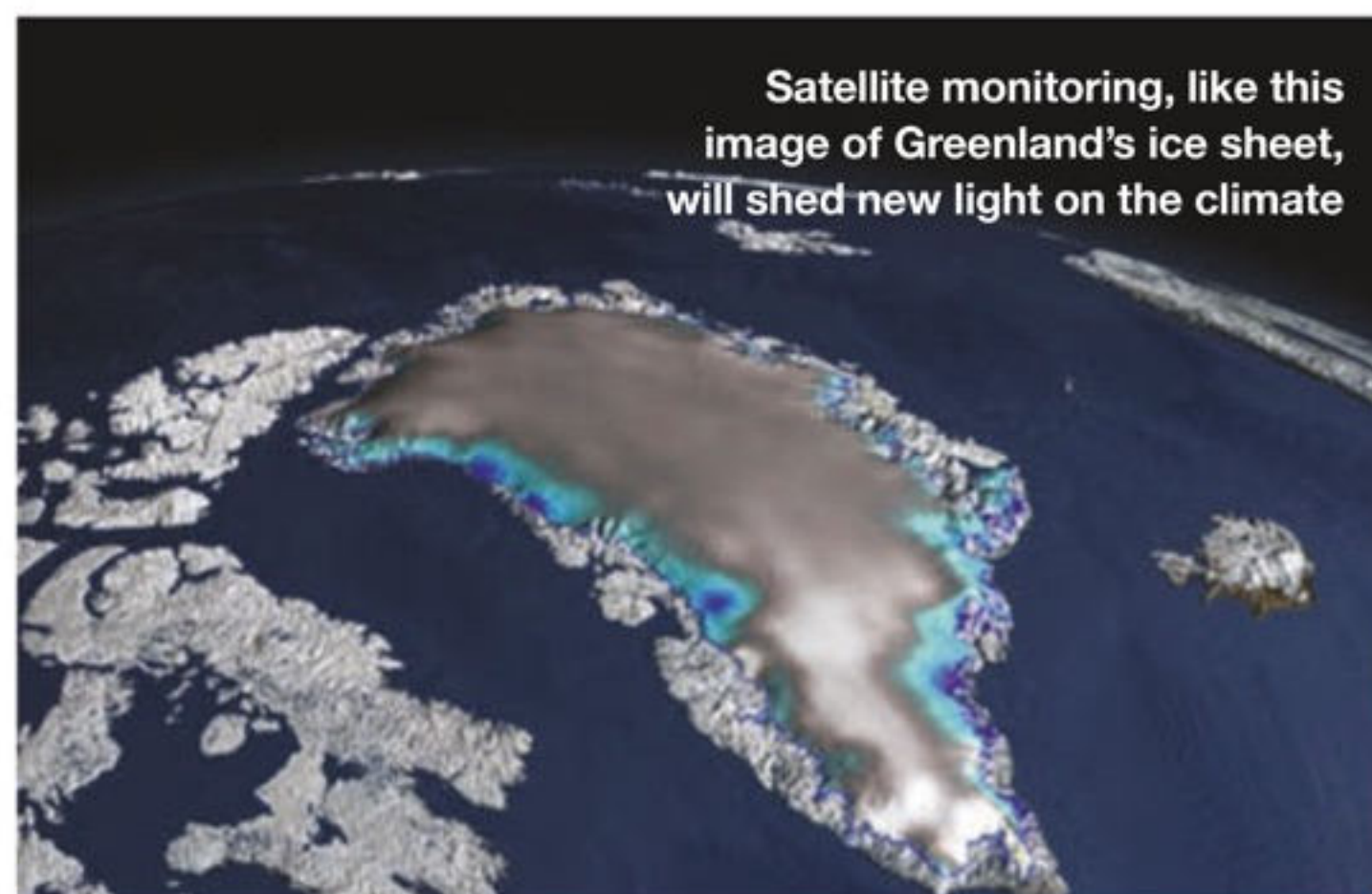
Director of the Climatic Research Unit at the University of East Anglia and an expert in global surface temperatures

“People will be looking at changes in sea ice, particularly in the Arctic. Outlet glaciers from Greenland and parts of the Antarctic will be monitored to see whether their melting is increasing, as it's important to know how much extra water is going into the oceans.

There are groups trying to integrate measurements from space with what is recorded on the surface. Satellites are trying to measure sea surface temperatures, and integrate those

with data from ships or drifting buoys. There's work going on there that's going to be useful in the long run.

Not all of the world is monitored adequately so, maybe using satellite measurements and reanalysis, a more consistent analysis of the weather over time will show if we're experiencing an increase in extreme weather. But the main issue in 2012 will still be that of more confirmation – it's what the public and some governments need.”



Satellite monitoring, like this image of Greenland's ice sheet, will shed new light on the climate



ARCHAEOLOGY

Brian Fagan

Professor Emeritus of Archaeology at the University of California, Santa Barbara

“There are areas of the world that are still little known to archaeologists and where I think huge discoveries are likely to be made. China, I think, is going to be significant – India and Pakistan too.

In Southeast Asia, the area around Angkor Wat is particularly important. They're now starting to study things like the hydrology of the site – how this huge monument survived and managed water. I would say the chance of a major discovery in one of these regions is pretty good.

Another area is East Africa, where there are constantly new human finds being made that really throw light on early human evolution.

But there's no question at all that the other big area is going to be remote sensing technology. It looks at subsurface features

and landscapes and it's truly revolutionary. In a week you can find more than many archaeologists find in months. Professor Vince Gaffney of Birmingham University is currently using the technology at Stonehenge.

It's going to have a huge impact. It enables us to look at entire landscapes at a site, like the area around Stonehenge, in much less time and in much higher resolution. It's far cheaper than walking and digging and it's a wonderful way of spotting a site so you can preserve it – that's really important.

It also looks at sites in their landscapes – showing the way people interacted with their landscapes is terribly important. A lot of archaeology now isn't concerned with treasure, it's concerned with knowledge.”



This instrument measured differences in Earth's magnetic field to reveal stoves and fireplaces at Stonehenge

Fagan's best of 2011

- Advancements in radio carbon dating played a crucial role in 2011. The dating of the Manis Mastodon bone, which proved that humans inhabited North America far earlier than previously thought, was one of the most important applications of the technology.



COMPUTING *Chris* **Bishop**

Distinguished Scientist at Microsoft Research Cambridge and Professor of Computer Science at Edinburgh University

“We’re likely to see interesting progress in the way people and computers interact. In the early days, you had to have a PhD in mathematics to program a computer. Then we had the development of graphical user interfaces and computers became easier to use.

We’re seeing a lot of research now into interfaces that don’t involve physical objects – there’s no screen or keyboard. The person just walks in front of a camera or sensor, and they use gestures. That’s a much more natural thing to do than having to type on a keyboard.

This field is progressing quickly, partly because computers are getting faster and partly because sensors, particularly 3D sensors, are getting better. But there have also been a lot of developments in machine learning – the idea that a computer can work out the solution to a problem. Instead of someone writing rules for the computer, it’s simply provided with the data and it uses that data to learn how to solve the problem.

In years gone by, when we wanted a computer to understand movements, we tried to program it with rules. But there has been little progress using that approach. The new approach is to get lots of people to stand in front of a sensor and make gestures. We then use that training data to teach the computer how to recognise and understand these actions.

Machine learning will also be applied to the medical domain. There’s been a huge expansion of data with the growth of electronic records. In the real world, there are all sorts of

“We’re seeing a lot of research now into computer interfaces that don’t involve physical objects – there’s no screen or keyboard”

natural experiments going on – some people are being given a particular drug, for instance, and some people aren’t. Machine learning can be used to model and analyse that rich data and give us interesting information, such as whether a drug is effective, or whether a new disease is emerging. It will also help us to combine disparate pieces of information, such as data about diabetes and heart disease and pull out interactions. We’re going to see an interesting transfer of ideas from technology to biomedicine. ”

Bishop’s best of 2011

- If the mathematical basis of the cryptography we use to send information privately over the internet has errors, a hacker may be able to defeat it. The best paper prize at Crypto 2011 was awarded for showing how a computer could check the maths.
- Published papers are promising improvements in how we distribute tasks across multiple data centres in cloud computing.



Gesture recognition systems, like this one in a US hospital, are at the frontline of computing



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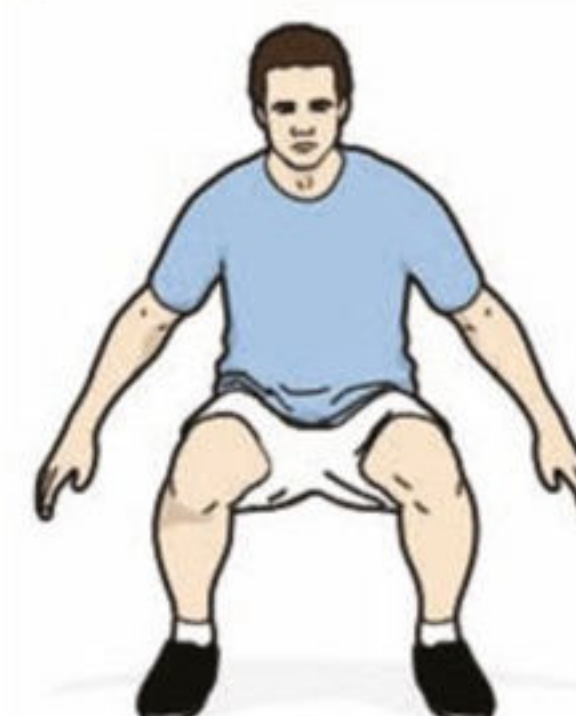
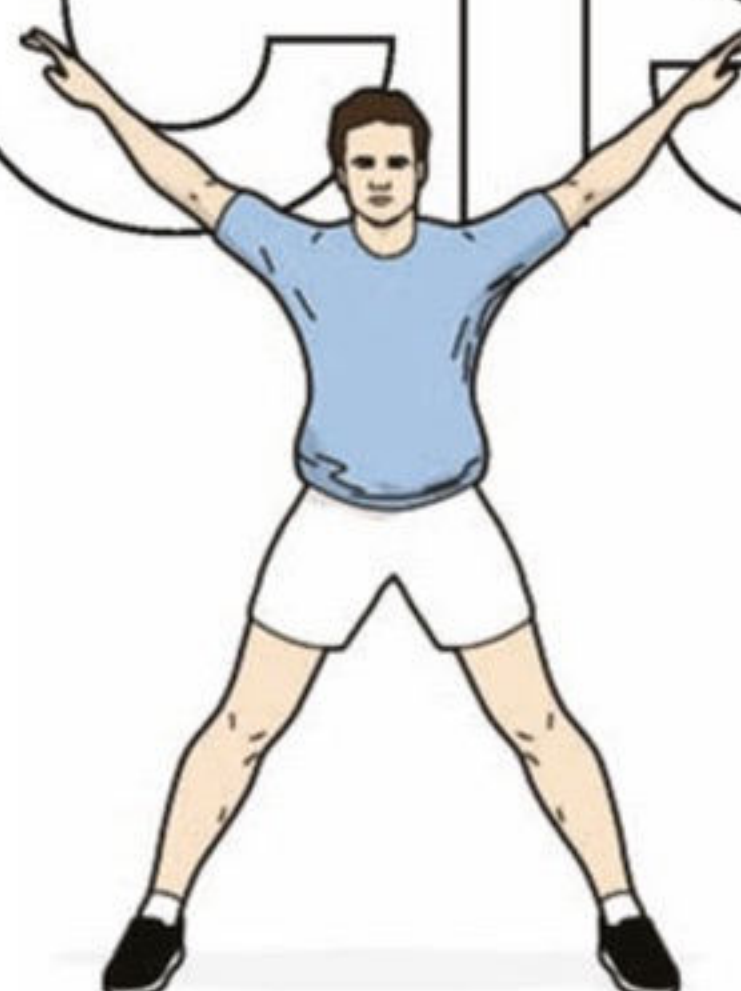
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THE TRUTH ABOUT EXERCISE



Losing weight is a common New Year's resolution. But as **Michael Mosley** discovered when filming for *Horizon*, exercise may not be the best way to do it

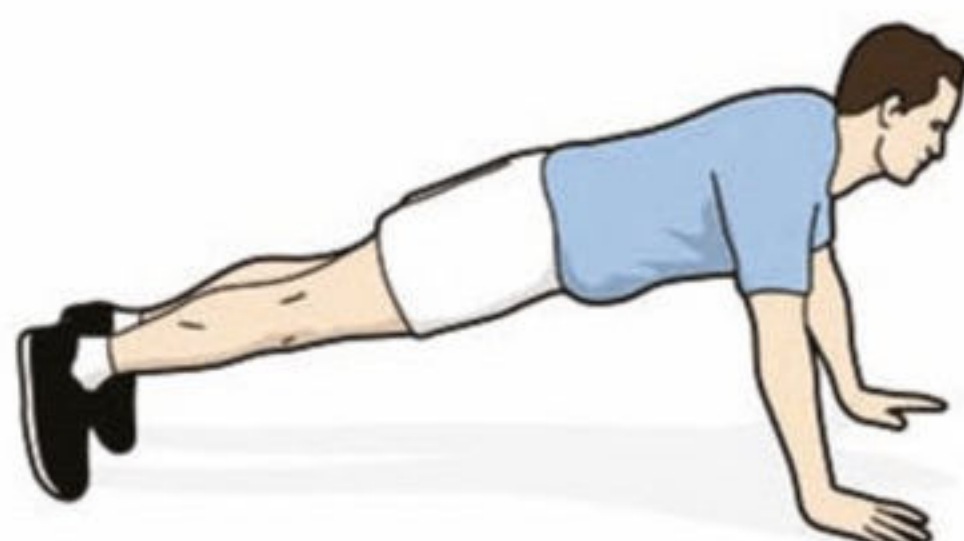
You might imagine shedding pounds to be straightforward: do more exercise, burn calories, lose weight. Unfortunately it's not that simple, as I discovered when filming *Horizon: The Truth About Exercise* for BBC Two. Results from the latest studies seem counterintuitive,

but scientists are at least getting closer to understanding why.

One study at the University of Pittsburgh put nearly 200 overweight women on an intensive weight-loss programme for two years. The women were asked to reduce their calorie intake – they had to consume less

than 1,500 calories a day – and to up their exercise levels.

To make sure they kept to the programme they were given lots of support. This included treadmills to take home and regular meetings and phone calls urging them to keep going. Initially all went well. Six months ►





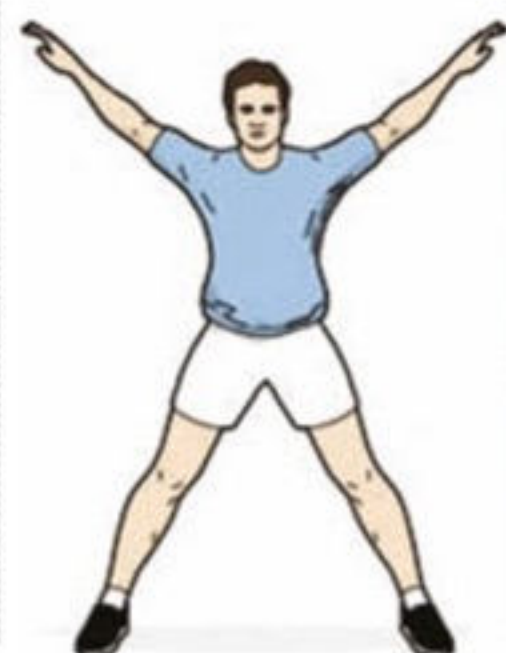
► after starting the programme, over half the women had lost at least 10 per cent of their body weight and most were still doing regular exercise. Then, as often happens, it all began to fall apart. Most of the women relapsed and started to regain the weight they had so painfully lost. Some did manage to keep going for two years but, to keep the weight off, they were having to do really significant amounts of exercise – nearly 70 minutes a day, five days a week.

But why is it so difficult to shed fat? Part of the problem is that fat is an incredibly energy-dense substance. A pound of fat contains more energy than a pound of dynamite, though it is rather less explosive. So you have to do an awful lot of exercise to burn it off. To find out just how much I went to Loughborough University where I was put through my paces by Dr Keith Tolfrey.

Dr Tolfrey, a senior lecturer in Loughborough's School of Sport, Exercise and Health Sciences, asked me to wear a face mask attached to mobile monitoring equipment. The equipment, he told me, would measure the amount of oxygen I inhaled and the amount of carbon dioxide I exhaled. From that he could calculate the number of calories I burnt doing exercise.

When it was all set up, Keith got me to run at a brisk pace around

Studies suggest that we compensate for exercise sessions by doing less



the track, while he cycled alongside shouting encouragement. I wasn't exactly going at Olympic pace, but I was going fast enough to feel relieved when, after 10 minutes, Keith told me I could stop.

The data-gathering machine showed I had burnt a grand total of 80 calories. This was not encouraging. As Keith pointed out, a small bar of chocolate contains about 240 calories, while a chocolate muffin comes in at an impressive 520 calories. "If you translate that into minutes of exercise," Keith announced, "you would need to run for half an hour to burn off the chocolate and for nearly an hour to undo the effects of eating a single muffin."

The trouble is that the bad news doesn't end there. Studies show that

humans don't stick to their normal food intake when they begin to exercise. Instead they compensate by eating more. In fact, even the thought of exercise may encourage you to start eating.

Changing your appetite

In a study carried out at the University of Illinois in the US, students were asked to evaluate the effectiveness of some leaflets. The students were split into two groups. Some looked at leaflets encouraging them to do more exercise and others looked at leaflets urging them to make friends. Afterwards they were asked to eat raisins, to rate their flavour. The students who had been shown the exercise leaflets ate a third more raisins than the other group.



GET FIT WITH SCIENCE

What the latest research tells us about maximising the benefit of exercise

This was hardly a real-world experiment, but there is plenty of evidence from the real world of calorie-eating compensatory behaviour.

“The initial effect of exercise is often to decrease appetite,” Dr Jason Gill at the University of Glasgow’s Institute of Cardiovascular and Medical Sciences told me. “The trouble is we may later decide to reward ourselves after a heavy session in the gym with a bar of chocolate or a full-fat cappuccino. There’s also evidence that we unconsciously eat to fill the energy gap, or compensate for increased activity by doing less when we aren’t exercising.”

Studies that suggest your body will try to sabotage your attempts to lose weight are supported by something called Set Point Theory. This theory ►



EXERCISE AT THE RIGHT TIME

Exercising in the night or evening may lead to larger increases in thyrotropin and cortisol than morning and afternoon workouts. Thyrotropin boosts metabolism, so exercising late may help to boost weight loss. Cortisol tends to increase the energy available for muscular activity – perhaps allowing more prolonged and intense activity, helping to boost fitness.



DO THE RIGHT EXERCISE

It’s hard to lose much weight through standard exercise regimes, but it is possible. The best way to shed weight by exercising is not to maintain a steady pace, but to do high-intensity intermittent training combined with a general increase in your overall level of activity. Occasional sprints, whether on a bike or on foot, are better than going steady.



DRINK BEETROOT JUICE

This won’t actually make you fitter but it will make you feel fitter. Research done at Exeter University has shown that drinking beetroot juice allows people to exercise for up to 16 per cent longer by dilating blood vessels and increasing blood flow to muscles. You have to drink at least a glass of concentrated juice a day to get a measurable result, though.



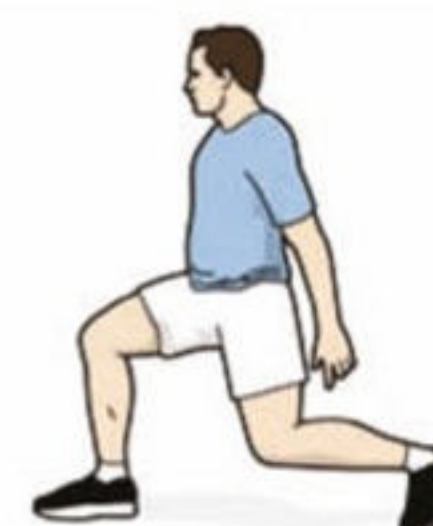
KEEP PUSHING YOURSELF

Research at the University of Sussex has shown that your brain normally steps in when you first start to exercise to protect you from pushing yourself too far. The less fit you are, the more susceptible you are to the messages coming from your brain saying: “It’s time to stop and have a nice rest.” If you persist, over time these messages will reduce in intensity.



MEASURE YOUR FITNESS

How do you know if what you’re doing is actually making any difference? The most widely accepted way of measuring aerobic fitness is $VO_2\max$ – the maximum amount of oxygen your body can use during a period of intense exercise. To measure it you would normally need to go to a lab but a quick online search will provide some simple ways to calculate yours.



Michael Mosley finds out just how much exercise is required to burn off part of a muffin

CAN YOU OVER-TRAIN?

How doing too much exercise can be harmful



Some injuries seem to be an inevitable part of sport. Arthritis of the lower joints, for example, is more common in footballers and endurance athletes than in the normal population and a study of former PE teachers in Sweden turned up some pretty disturbing findings. In the study, published some years ago in the *Journal Of Occupational And Environmental Health*, the researchers tracked down more than 500 teachers who had qualified between 1957 and 1965. They found that the teachers now had higher rates of arthritis of the knee and hip, which needed replacement surgery in some cases.

And it's not just joints. A study in the June 2011 edition of the *Journal Of Applied Physiology* found that half of serious marathon runners and rowers showed early signs of myocardial fibrosis, or scarring of the heart. It can lead to irregular heartbeats that, in turn, can lead to more serious problems. It's worth mentioning, though, that the men who were studied had undergone immense amounts of training, far more than the average distance runner. The good news is that this damage seems to be reversible – at least it is in rats.

► was originally developed in the early 1980s and has a lot of experimental backing. It's an attempt to explain why so many people who try to lose weight through exercise, dieting or some combination of the two, fail. The answer seems to be that your body will do everything in its power to keep your weight steady.

We're familiar with the idea that balance, or homeostasis as it's known, is crucial to how our bodies function. The reason we're able to walk around in all sorts of weather is because our bodies regulate our internal temperature with a high degree of accuracy. Whether it's 40°C or -10°C outside, your body will keep your core temperature at 37°C.

Set Point Theory suggests that just as we have an internal thermostat, we also have an internal weight sensor. Once you reach a certain weight your body will do all it can to make sure you don't lose any of it. There seem to be a number of different ways your body works to ensure that it clings onto that unwanted fat (unwanted, that is, by you).

Imagine you are overweight and decide to lose a few kilos. You go on a diet and increase the amount of exercise you do. Initially the results are spectacular. The weight drops off with relatively little effort. Great. But then it stops dropping off. You've cut your calories, increased your activity but nothing is changing and

VITAL STATISTICS

10 to 20

times more calories were eaten by children than they had just burned in exercise sessions in a study carried out by scientists in Boston, USA.



calories are typically burned off in a two-hour bike ride.

45 million

people in the US belong to a health club and spend \$19 billion (£11.9bn) a year on gym memberships.



calories per day are burned by a pound of muscle in a resting body according to calculations by a Columbia University team.

you are constantly hungry. What's going on?

Well, as you lose weight your metabolic rate slows down, simply because you're carrying around less weight than you were before. But the amount your metabolic rate slows can't be explained simply by weight loss. It seems that your body also becomes more efficient at storing and using calories. At the same time hunger hormones, like ghrelin, kick in telling you to eat more.

The reason for all this activity is that once upon a time, it was an essential survival adaptation. When our distant ancestors found themselves in a famine situation it was essential that their bodies responded by conserving energy in whatever ways they could until the good times returned.

These days, living in an energy-rich food environment, this tendency to hold onto fat is incredibly frustrating. So what can you do about it?

The short answer is don't get fat in the first place. The flip side of the body's attempts to stop you losing weight is that it'll also stop you trying to put on too much weight. Assuming, however, that you are already overweight, then your best bet is to set a realistic target to reduce your body weight by a maximum of 10 per cent, and take plenty of time over doing it.



Energy-rich food is abundant in the developed world today, unlike in the past



Nobody knows how long it takes for your body to grudgingly accept that the new, lighter version of you is 'normal' – it's probably years. It may be never.

Pointless exercise?

But exercise isn't just about losing weight. Anything that raises your pulse a bit appears to lower your risk of all sorts of diseases, including heart disease, Type 2 diabetes, stroke and some cancers. Although even here it's not simple.

One measure of how fit and healthy we are is our $VO_2\text{max}$ – the maximum volume of oxygen our bodies can use during exercise. It's determined by the amount of blood our hearts can pump and the ability of our muscles to take up oxygen. Scientists believe our $VO_2\text{max}$ is one of the best predictors of health and longevity.

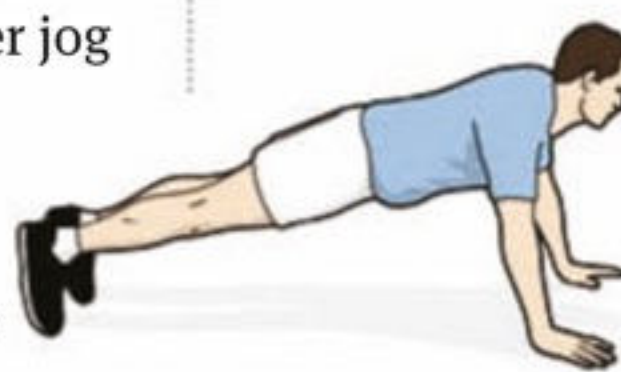
Although aerobic exercise, such as a brisk walk or run, tends to increase $VO_2\text{max}$ over time, not everyone responds to the same extent. In

fact, some people's $VO_2\text{max}$ doesn't improve with exercise – so a bike ride or swim may not ward off heart disease and some other conditions.

A team of researchers led by scientists at the Royal Veterinary College, University of London and the University of Copenhagen pooled the results of three studies to identify about 30 genes that appear to have an influence on how someone's $VO_2\text{max}$ will respond to exercise. It suggests that in future, a genetic test may tell you how much you stand to gain from a workout, making it a good investment before you buy a gym membership or go for yet another jog around the park. ■

Dr Michael Mosley is a TV presenter and Focus columnist

Exercise can reduce your risk of some diseases, even if it may not help you lose weight



**BBC
TWO**

Dr Michael Mosley investigates fitness in *Horizon: The Truth About Exercise* on BBC Two in January. Check www.radiotimes.com for broadcast dates and times.



THE FUTURE OF WEIGHT LOSS

An injection that could help fight the flab

One of the hottest areas of research, when it comes to weight loss, is into the hormones produced by the gut that control appetite. The two main hormones of particular interest are leptin and peptide YY (also known as PYY), both of which suppress appetite.

Leptin normally acts on the hypothalamus in the brain, suppressing hunger signals. There was, in the 1990s, a widespread belief that a simple injection of leptin would reduce the appetite of obese patients. Unfortunately it's not anything like that easy. Researchers soon discovered that most overweight people are not deficient in leptin. Far from it – they often have extremely high circulating levels. It seems that they have become insensitive to leptin and research is now focused on why this happens.

PYY seems to offer more immediate hope. It's secreted in response to eating and reduces the rate at which the stomach empties and reduces appetite. In a study carried out at the Hammersmith Hospital in London, researchers injected volunteers with PYY and noticed that on average they ate a third less than they previously had when offered a buffet lunch. Clinical trials are currently underway.



The leptin molecule – overweight people often have a lot of them



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The Chemistry of CHRISTMAS

Holiday traditions boiled down to their very essence

CRACKERS

The bang in a cracker comes from the violent reaction of a mixture known as percussion powder, once used to ignite the charge of gunpowder in a pistol. In a cracker its chemical reaction is triggered by friction as the two roughened ends of the snap are pulled apart. The percussion mixture consists of antimony sulfide (Sb_2S_3) and potassium chlorate (KClO_3). When these are forced together they react explosively: the equation is $\text{Sb}_2\text{S}_3 + 4\text{KClO}_3 \rightarrow \text{Sb}_2(\text{SO}_4)_3 + 4\text{KCl}$. Unlike other explosives, which rely on the massive release of a gas to create a shock wave of noise, percussion powder simply relies on the sudden release of energy to create the bang.



ALCOHOLIC DRINKS

Drinks tend to be an enjoyable part of Christmas Day, but their aftereffect can be an unpleasant hangover on Boxing Day morning. By then, the ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) which the drinks contained has been converted by enzymes to ethanal (CH_3CHO), a nasty chemical that causes the headache and nausea we associate with a hangover. The body eventually converts this to ethanoic acid ($\text{CH}_3\text{CO}_2\text{H}$), but only slowly, and finally to carbon dioxide after its energy has been extracted. The enzymes that convert ethanol need fructose to operate efficiently, so a breakfast of honey on toast should help speed its removal.



CANDLES

Candles are a traditional part of Christmas, and of the Jewish festival Chanukah, which occurs at this time of year. Candle wax now comes from the petrochemical industry and is saturated long-chain hydrocarbons – these burn with a smokeless flame. Traditional candles are made from the hard tallow fat of sheep and cows and it burns with a slightly smoky flame because it contains unsaturated fatty acids with double bonds ($\text{C}=\text{C}$). Chemically, tallow is a triglyceride, which means it has three fatty acid chains attached to a glycerol molecule. Monounsaturated oleic acid is the largest component.



CHRISTMAS TREES AND LIGHTS

Artificial Christmas trees are generally made of PVC, and some have fibre-optic cables to transmit light from a bulb in the base to the ends of the 'branches'. Alternatively, fairy lights can be used and these rely on light-emitting diodes, LEDs. Their colour depends on the chemical elements from which they're made. For example, aluminium gallium arsenide (AlGaAs) shines red, aluminium gallium phosphide (AlGaP) is green, and gallium nitride gives blue (GaN). Gallium nitride combined with silicon carbide gives a bright white light.



CHRISTMAS DINNER

A typical feast of turkey, stuffing, roast potatoes, Brussels sprouts, gravy, Christmas pudding, brandy sauce, mince pies, cream, cheese, biscuits, chocolates, sweets and Christmas cake, along with wines and liqueurs, provides around 5,000 kilocalories of energy, twice what we need for a day's eating. The body stores the excess food energy as glycogen, a polymer made of linked glucose molecules. If you go on a diet in the New Year, most of the surplus glycogen is used up before it can be converted to triglyceride fat for long-term storage.

INDIGESTION TABLETS

Christmas is a time of overeating. The stomach produces hydrochloric acid (HCl) to aid digestion and the more we eat, the more acid it produces, until there is too much for comfort. We can remove a lot of this acid with antacid tablets or indigestion mixtures. These are alkalis – the opposite of acids, with whose hydronium ions (H⁺) they react and neutralise. A calcium carbonate tablet acts like this: $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$. (The carbon dioxide may make us burp.) Other remedies use sodium hydrogen carbonate (aka bicarb), which also releases CO₂ or magnesium hydroxide (aka milk of magnesia), which doesn't.



ARTIFICIAL SNOW

This consists of a mixture of finely powdered calcium carbonate (CaCO₃) whose particles are coated with sorbitan tristearate wax made from sorbitol, a fruit sugar, and stearic acid, a saturated fatty acid made from plant oils. Sorbitan tristearate keeps the particles of CaCO₃ dispersed in the can and also makes the 'snow' stick to the surface it is sprayed on. The propellant that ejects the 'snow' is a mixture of liquefied propane gas (C₃H₈) and isobutane gas (C₄H₁₀). Some of this evaporates as the pressure is released and this expels the 'snow' from the can.



PERFUMES

Perfume was one of the very first Christmas presents, delivered as frankincense and myrrh to the newborn child. Perfumes today consist of various essences in ethanol (alcohol) and are a blend of so-called top notes, which are the most volatile chemicals and have a fresh smell, middle notes that provide the heady aroma of blossom, and base notes, which are described as 'animalistic'. Although some fragrances are extracted from plants, most are now produced by the chemical industry. Chanel No.5 was the first to use a chemically derived scent, 2-methylundecanal (CH₃(CH₂)₇CH(CH₃)CHO), which has a fruity incense-like odour.

John Emsley is a chemist at the University of Cambridge and the author of *Nature's Building Blocks*



Feed your mind



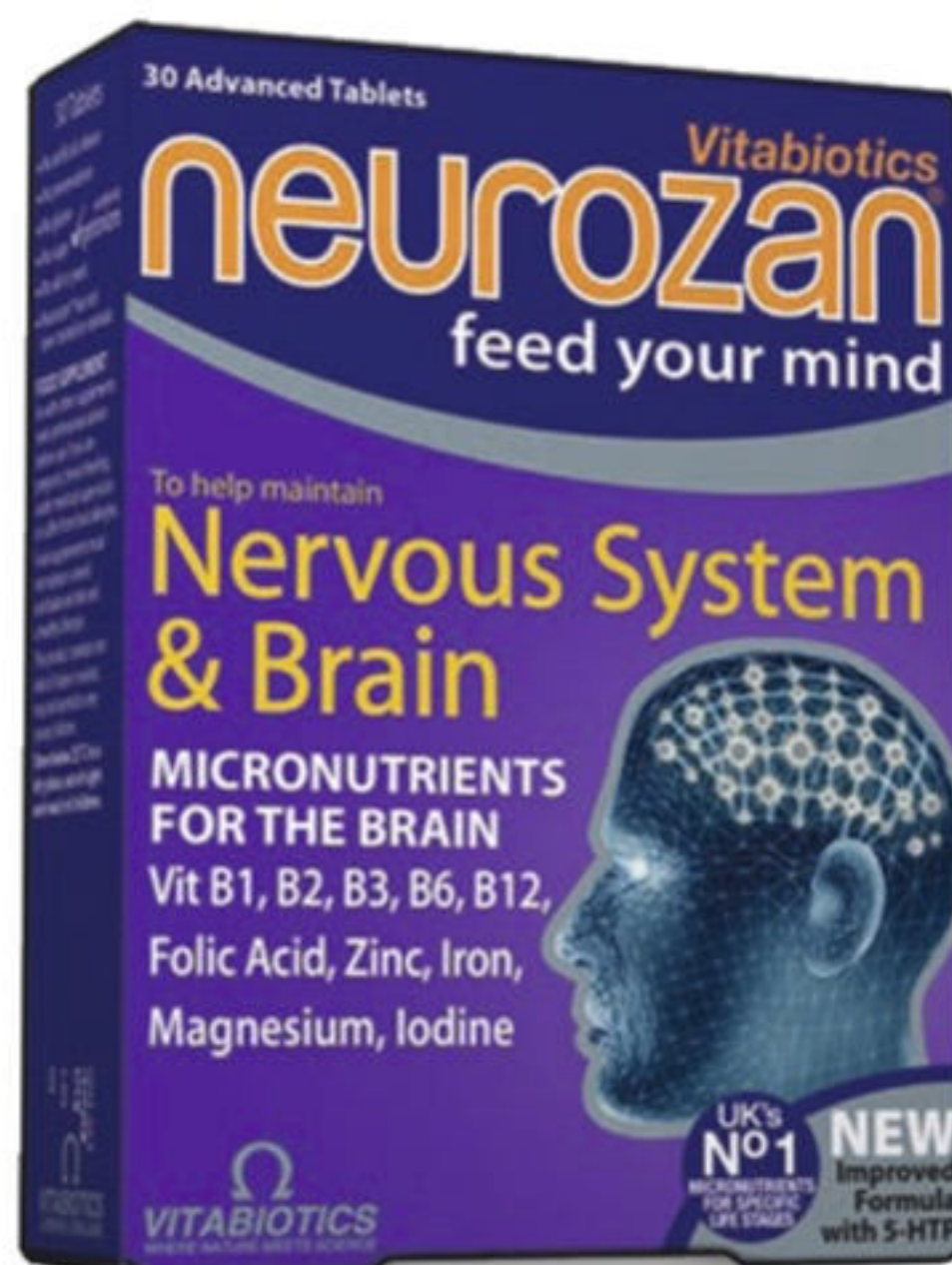
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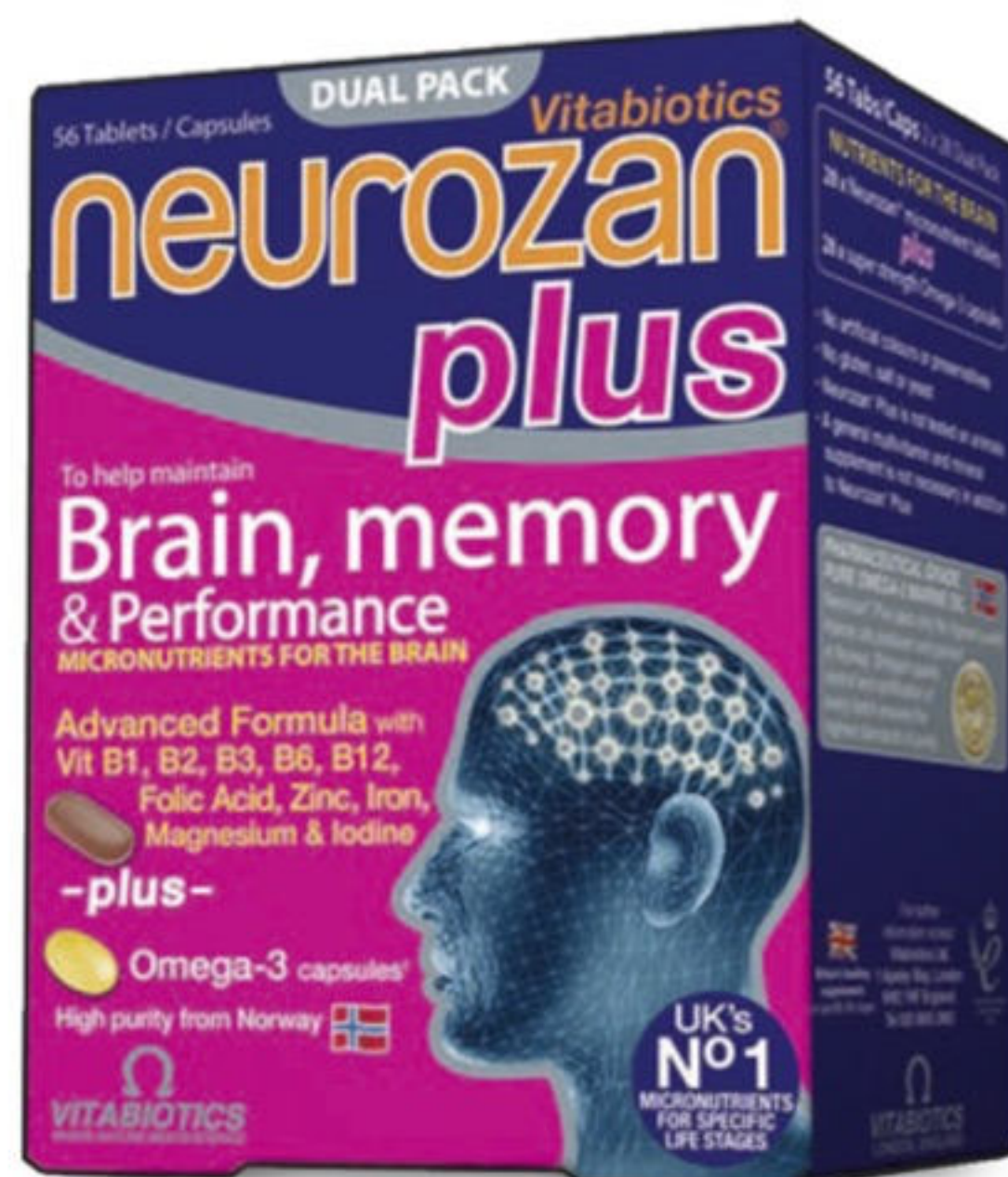
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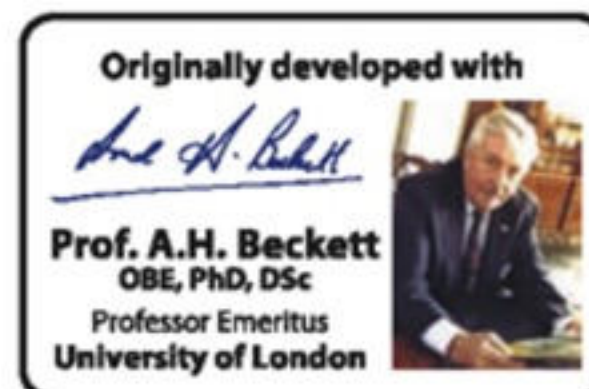


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THE THINKING CITY

In South Korea, just west of Seoul, real estate companies, building contractors and a computing giant have collaborated to create the most high-tech place on the planet. **Charles Arthur** investigates



The city streets of Songdo in South Korea look deserted. For a city of the future, there isn't a lot there right now. It's only half-complete. Even so, 22,000 people already live there, with another 5,000 expected to join them by the end of 2012.

The plan, though, is that when finished in 2015, Songdo's 6km² (almost 2.4 miles²) area will be home to 65,000. And they'll be living in the world's 'smartest

city' – a measure not necessarily of the inhabitants' IQ but of the intelligence built into Songdo's roads, parks and tower blocks.

This brand-new 'smart' city is a huge, and hugely ambitious, project. It's being built on an artificial island about 56km (35 miles) west of Seoul, the capital of South Korea. It's meant to be a glimpse of what Seoul, future cities and even existing European cities could look like in years to come.

And we will need more smart cities. The United Nations forecasts that by 2050, cities will house 70 per cent of the world's population, or 6.4 billion of a total 9.2 billion. Cities are already home to half of the world's 7 billion population. Adding another 3 billion people to our cities will strain the existing ones to their limits.

The solution, according to the people behind Songdo, is to build an intelligent city. A city that ►

► will be capable of reacting to its residents and the environment within and around it.

Building links

Begun in 2000, Songdo is the largest private real estate venture in history – its current estimated cost is \$35 billion (£22 billion). The majority of the money has come from Gale International, an American private real estate firm, and the investment bank Morgan Stanley.

This investment is, in part, being made to create an ‘internet of things’ (see Building a smart city, right), linking not just people but also objects like cars and homes over the internet. To create this, the city’s planners have turned to telecommunications giant Cisco. As the city has been constructed, Cisco has wired up every square inch, embedding sensors in the city’s roads, streets and buildings. Each one will send a constant stream of data to a central control hub. At the hub, data about the city’s buildings, power demand, road and traffic conditions, external and internal temperatures, will be collected and analysed.

According to Cisco’s chief John Chambers, they’re building a city

that will “run on information”, with the control hub acting as Songdo’s “brain stem”. For example, street cameras will monitor how many pedestrians are on the pavement. To reduce running costs, the lights can then be dimmed on empty streets and brightened on busy ones. Unusual stresses detected on the roads or structures can also be flagged up, to pre-empt costly delays caused by major roadworks.

Furthermore, to prevent the traffic problems that every city faces, radio-frequency identification (RFID) tags will be stuck to vehicles’ number plates. These are tiny aerials tuned to a specific frequency, connected to an ultra-low-power processor.

When the RFID tag’s aerial detects the frequency it’s tuned for, the electrons in the metal oscillate. In effect it ‘rings’, rather like when you rub a wet finger around a wine glass, except that this ringing is electrical energy. The energy powers a processor, which then decodes the digital signal. If the signal is authorised, the RFID chip sends a signal identifying itself back to the control hub on the same frequency. This all happens in less than a second, and as every car in the city ►



Songdo's 100-acre Central Park will occupy six per cent of the city's land – the same proportion of land covered by Central Park in Manhattan, New York



Water from sinks, washing machines and dishwashers will be recycled and used for irrigation.

Cisco-installed broadband will run to every home and office offering high-speed fibre-optic connections to the rest of the city and the world outside.

Both dry and wet waste are removed via a pressurised network of pipes, eliminating the need for rubbish collection.

BUILDING A SMART CITY

How Songdo's architects are creating an internet of things

Future plans include a high-speed train to transport people the 56km (35 miles) to the capital Seoul in about 20 minutes.

The control hub will monitor weather forecasts, and prepare for surges in power demand, such as when the city's residents collectively turn their heating up.

Electrical appliances will draw power from a 'smart grid'. Data on usage patterns is gathered by the control hub, which prepares for peaks and troughs in demand. If this existed in the UK, the grid would ready itself for the national tea-breaks that follow football or *EastEnders*.

Homes will be fitted with touch-panels to let people control lighting and heating directly, as well as track their exact energy usage. Studies show that when people get direct feedback about how much electricity they're using, they reduce it.

Rooftop vegetation will absorb heat, reducing the 'heat island' effect where cities are hotter than the surrounding area because concrete absorbs heat. Plants and soil will also absorb water and reduce run-off of stormwater to streets below.

Vehicle number plates will have 'smart tags', so if a road is empty, its streetlights can be turned off at night.

Sensors built into the roads will track vehicles as they make journeys across the city. This information is sent to the control hub that studies current traffic flow and previous trips, to determine the most efficient way to trigger traffic lights.

'Telepresence' video screens will be in every home and office, making video calling ubiquitous between Songdo's inhabitants. There'll even be video kiosks in the streets.

► is logged, it creates an exact picture of the current traffic situation, allowing the hub to adjust traffic light timings, create diversions and provide early warnings. Even Songdo's traffic lights are high-tech. Light-Emitting Diodes (LEDs) will replace light bulbs, using about one per cent as much power.

With this network put in place, Chambers says Cisco has gone from being like "a plumber" – by offering the basic equipment that routes data around the internet – to being "the platform for innovation".

The element expected to have the most resonance with residents, though, is the 'telepresence' video screens. These will eventually be in every home and office and even in the streets to let people make ad-hoc video calls wherever they are.

But the tech being built into Songdo is only part of the story. The aim of a smart city is to square the circle: to create something artificial, as a city is, that's also sustainable so that it has minimal environmental impact.

Cool, clean and green

The existing need for water puts enormous pressure on this resource. On average a resident of an American city uses 250-300 litres of water per day. In the Netherlands, the figure is half that. A new city will



This artist's impression of the city was created by Songdo's architects to draw in new residents to one of its 22,500 housing units

only exacerbate that pressure. But clever landscaping, rainwater traps and treatment of 'grey water' (the output from sinks, dishwashers and washing machines) will mean Songdo's irrigation systems will aim to use only one-tenth as much clean water. Planting vegetation on rooftops will reduce stormwater runoff. It will also combat the 'heat island' effect that any city generates: the plants absorb the Sun's heat and use it for photosynthesis, cooling the surrounding air.

But perhaps the most amazing thing is there won't be dustbin collections. Instead, a centralised, pressure-driven collection system for both wet and dry waste will whoosh rubbish away, so there won't be refuse lorries driving around.

But what makes a city truly smart? Professor Mark Deakin, head of the Centre for Sustainable Cities at Edinburgh Napier University, explains that it's a measurement made on many levels. "You can't simply pronounce somewhere a smart city just by appearances," Deakin says. "I don't really know whether you'd be aware of being in a smart city. I'm not sure if you'd suddenly say 'oh, this is smart now' or if it would be more of a slow realisation.

"A system [for a smart city] has to be bidirectional, so you can have smart energy applications." And that's precisely what Songdo's planners hope to create: a 'smart grid', in which the power company gets feedback from the systems in homes and offices. That way the energy company knows what the electricity is powering at any time, whether it's

dishwashers, kettles or lights. Each produces a characteristic signature that can be detected by smart systems connected to the grid. The result of all this feedback is an efficient energy network that can adapt to the demands placed on it.

And what of the future? Could London or Paris be turned into smart cities? "There are lots of cities in Europe – Amsterdam, Barcelona, Malmö, Stockholm – that are emerging with partnerships and joint enterprises with the citizens to make the cities smarter," says Deakin. "In a sense, upgrading old cities is like dentistry – you have to drill out what's rotting. To a degree it's possible, but the real question is whether the upgrading is being done for social reasons or if it's just a technology push."

Stan Gale, chairman of Gale International, has his own view on how smart cities will evolve. He has grand plans to create 20 new cities across China and India, for which Songdo will be a template. And Moore's Law – the one that rules computing, dictating its constant improvement – will ensure "each will be done faster, better, cheaper, year after year." ■

Charles Arthur is technology editor of The Guardian



Songdo's housing is mostly ready, but many of its office towers, like the one above, are still unfinished. The year 2015 has been set as the target completion date



Thinking Streets
BBC Radio 4,
3 January, 9pm

To find out more about intelligent city design listen to *Thinking Streets*, which reveals the new road scheme sweeping across Britain and Europe.

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SUPERSCOPES

As *Stargazing LIVE* returns to BBC Two, Dr Alastair Gunn reveals how giant telescopes will unravel the Universe's greatest mysteries



The next generation of ground-based telescopes will be even bigger than those that have gone before. They'll be better able to discover distant, Earth-like planets and help answer key cosmological questions such as how stars and galaxies first formed.

New telescopes will also shed new light on two of astronomy's biggest mysteries: the invisible 'dark matter' seen only by its gravitational 'tug' on other objects;

and 'dark energy', a phenomenon believed to be propelling the expansion of the Universe.

Big telescopes have a bigger 'bucket' for collecting light, so they're able to detect fainter objects and hence see further. There is a problem, though: the Earth's atmosphere absorbs, refracts and scatters light. It makes images fuzzy. One solution is to put instruments above the atmosphere and into orbit like the Hubble

Space Telescope. But this is both expensive and restrictive.

Luckily, advances in technology mean the next generation of ground-based superscopes will perform almost as well as those in space. Even so, sites for these telescopes will mostly be high, above as much of the atmosphere as possible.

So what do astronomers have planned for the new superscopes? Read on to find out about some impressive feats of engineering... ►



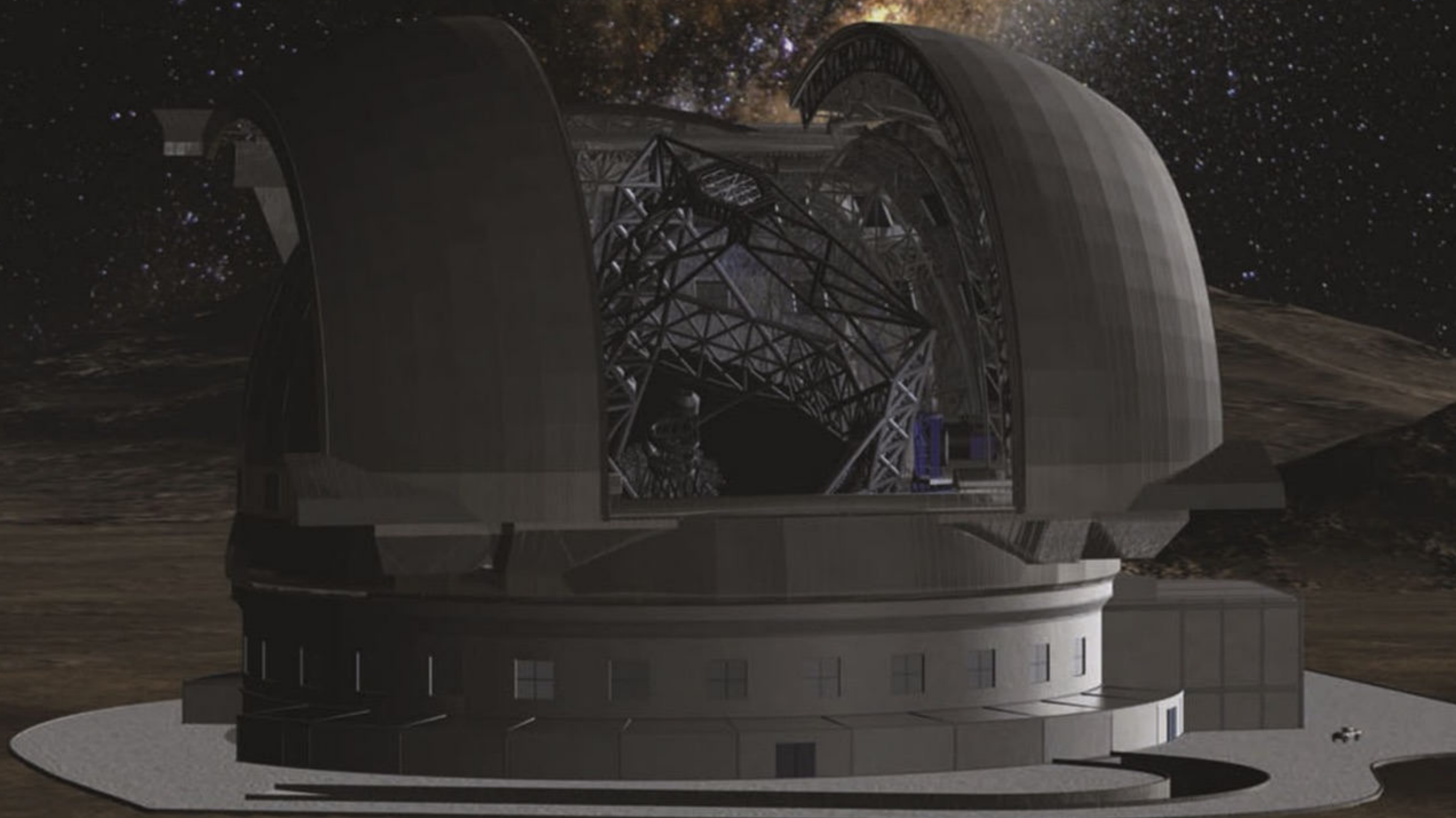
Dr Alastair Gunn is a radio astronomer working at Jodrell Bank Centre for Astrophysics

E-ELT

(European Extremely Large Telescope)



Number of mirror segments	1,000
Diameter of main mirror	39.3m
Location	Cerro Armazones, Chile
Altitude	3,060m
Cost	£950m (€1.1b)
Completion date	2020



One of the most eagerly awaited superscopes is the European Extremely Large Telescope (E-ELT), an optical and near-infrared telescope with a main mirror that's almost 40m in diameter. At almost half the length of a football pitch, this is easily the largest mirror ever built – four times bigger than the biggest mirror in use today.

It's practically impossible to build a 40m-mirror in one piece. Instead, the E-ELT's collecting surface will be made up of around 1,000 hexagonal segments, each 1.4m wide. Although sited high above most of the water vapour that absorbs starlight, the E-ELT will still be gazing through a thick blanket of air. To compensate for this, the mirror will

have more than 6,000 actuators that can change its shape a thousand times a second. Additionally, an extremely bright laser beam will be projected into the sky above the telescope to form an artificial star. By tracking how this point of light twinkles, the telescope will automatically correct itself. Using this technology, the E-ELT will easily surpass the achievements of the Hubble Space Telescope.

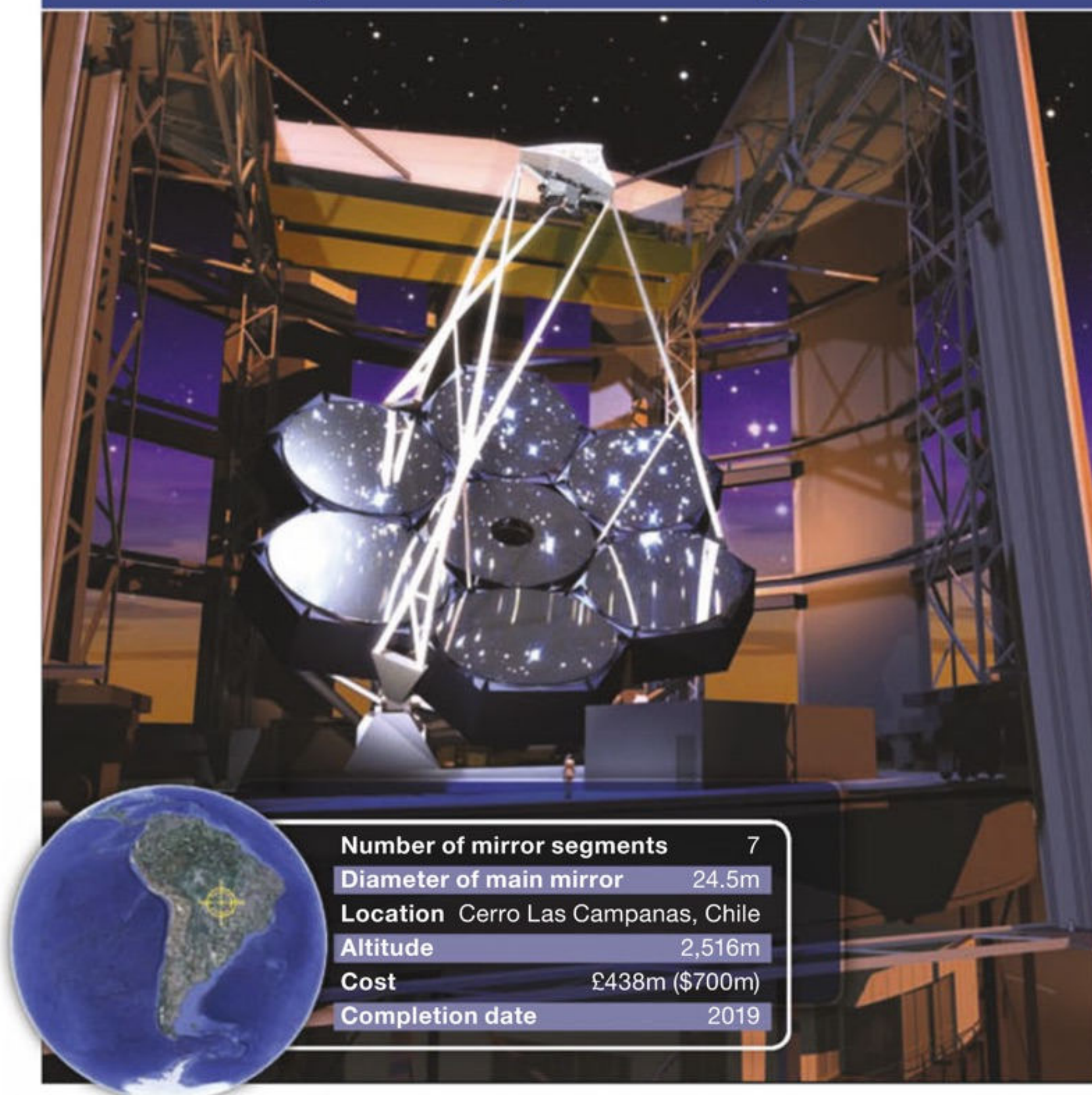
The E-ELT will tackle some of the biggest scientific challenges of our time, such as whether there's anyone out there. Although astronomers now know of more than 500 'exoplanets' orbiting stars other than our Sun, the E-ELT will likely be the first to find such planets within the 'habitable zones' of stars

– worlds where life might thrive. "The E-ELT will be capable of detecting life on planets around the nearest stars to our Solar System," says Professor Markus Kissler-Patig, project scientist for E-ELT at the European Southern Observatory in Garching, Germany. "I hope it achieves this immense goal."

The E-ELT will also be able to see much further into space than any telescope yet built, probing the very first stars and galaxies to form in the Universe. It will be able to measure the acceleration in the expansion of the Universe directly, and help solve one of astronomy's biggest mysteries: the nature of 'dark matter' – the missing 83 per cent of the Universe.

GMT

(Giant Magellan Telescope)



Number of mirror segments	7
Diameter of main mirror	24.5m
Location	Cerro Las Campanas, Chile
Altitude	2,516m
Cost	£438m (\$700m)
Completion date	2019

While the E-ELT is a predominantly European project, other nations have united to pursue similarly sized optical superscopes. The most notable is the Giant Magellan Telescope (GMT), developed by organisations in the US, Australia and South Korea.

Not quite on the same scale as the E-ELT, but still impressively huge, the GMT's main mirror will be 24.5m in diameter. Its reflecting surface will be made up of seven circular mirrors, each 8.4m in diameter and weighing 20 tonnes. It will take a year of grinding and polishing to give each mirror its required shape, accurate to within the thickness of aluminium foil.

The GMT's location, in the Chilean Andes, is arguably the best site in the world for astronomy. The dry conditions, high altitude, lack of pollution, clear weather and dark skies make it ideal. It's not surprising that five of the world's most important observatories are perched on its peaks. The GMT will be located at one of these sites, the peak of Cerro Las Campanas.

Just like the E-ELT, the GMT's optics will include mirror-warping actuators to compensate for the turbulence of the Earth's atmosphere. It will therefore have a resolving power 10 times higher than the Hubble Space Telescope – so sensitive that it could see a candle on the Moon.

Having a head-start on the bigger E-ELT, the GMT will begin the search for Earth-like planets and tackle the problems of dark matter, dark energy and cosmic evolution. But like all superscopes, it will undoubtedly throw up more questions than answers.

ALMA

(Atacama Large Millimeter/sub-millimeter Array)

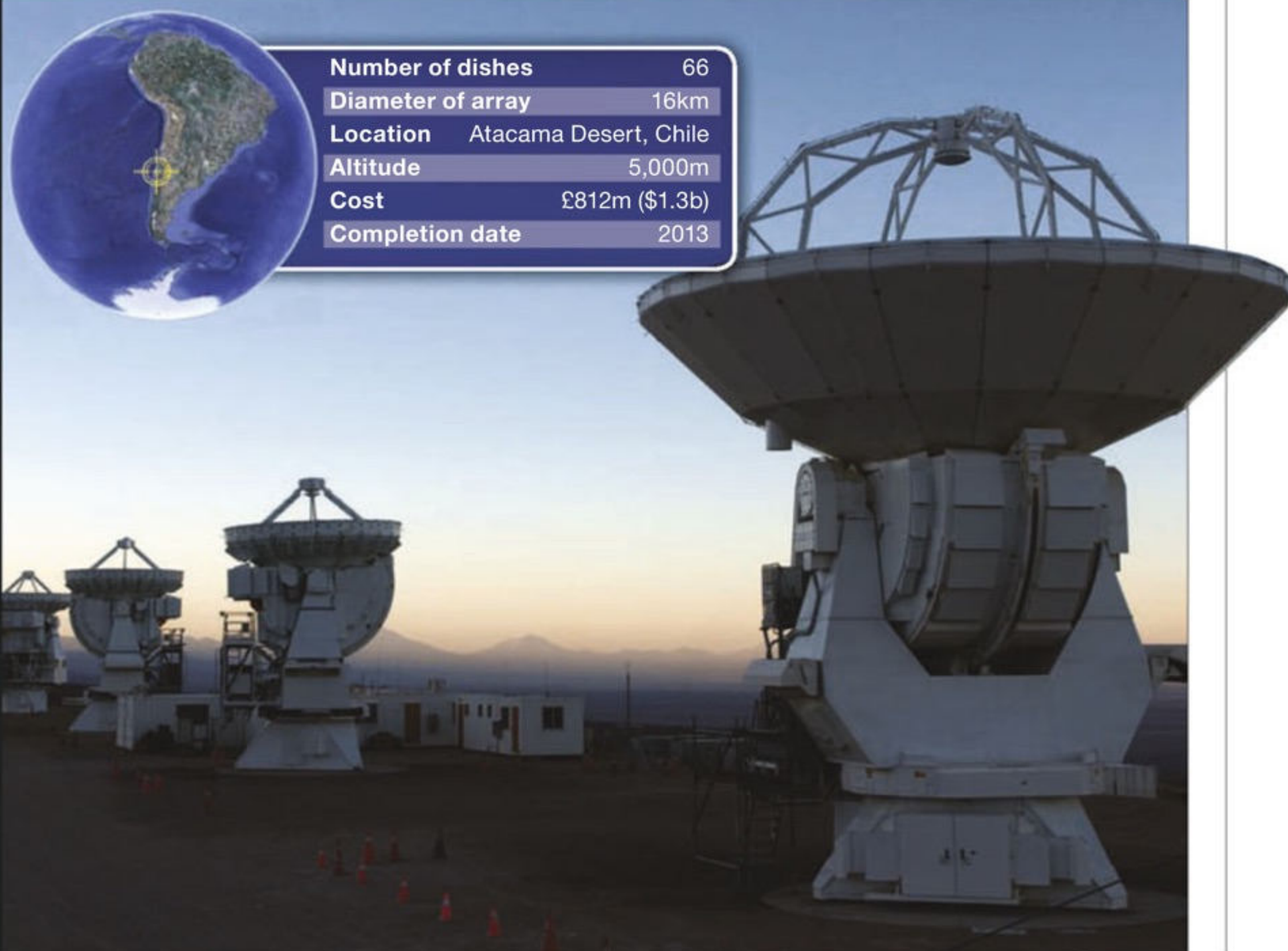
Radio and sub-millimetre astronomers study wavelengths of radiation many thousands of times longer than those seen by optical astronomers. So to get the kind of image you'd obtain from a typical optical 'scope would require an instrument many hundreds of kilometres wide. To overcome this problem, radio and sub-millimetre astronomers often use an 'interferometer' – an array of widely separated telescopes combined to form a 'virtual dish'.

ALMA is just such an interferometer. Currently under construction but already making images, ALMA will eventually consist of fifty-four 12m dishes and twelve 7m dishes, spread over an area 16km across. It already boasts the most powerful non-military computer on the planet and, when finished, will generate a staggering 800 gigabytes of data per day.

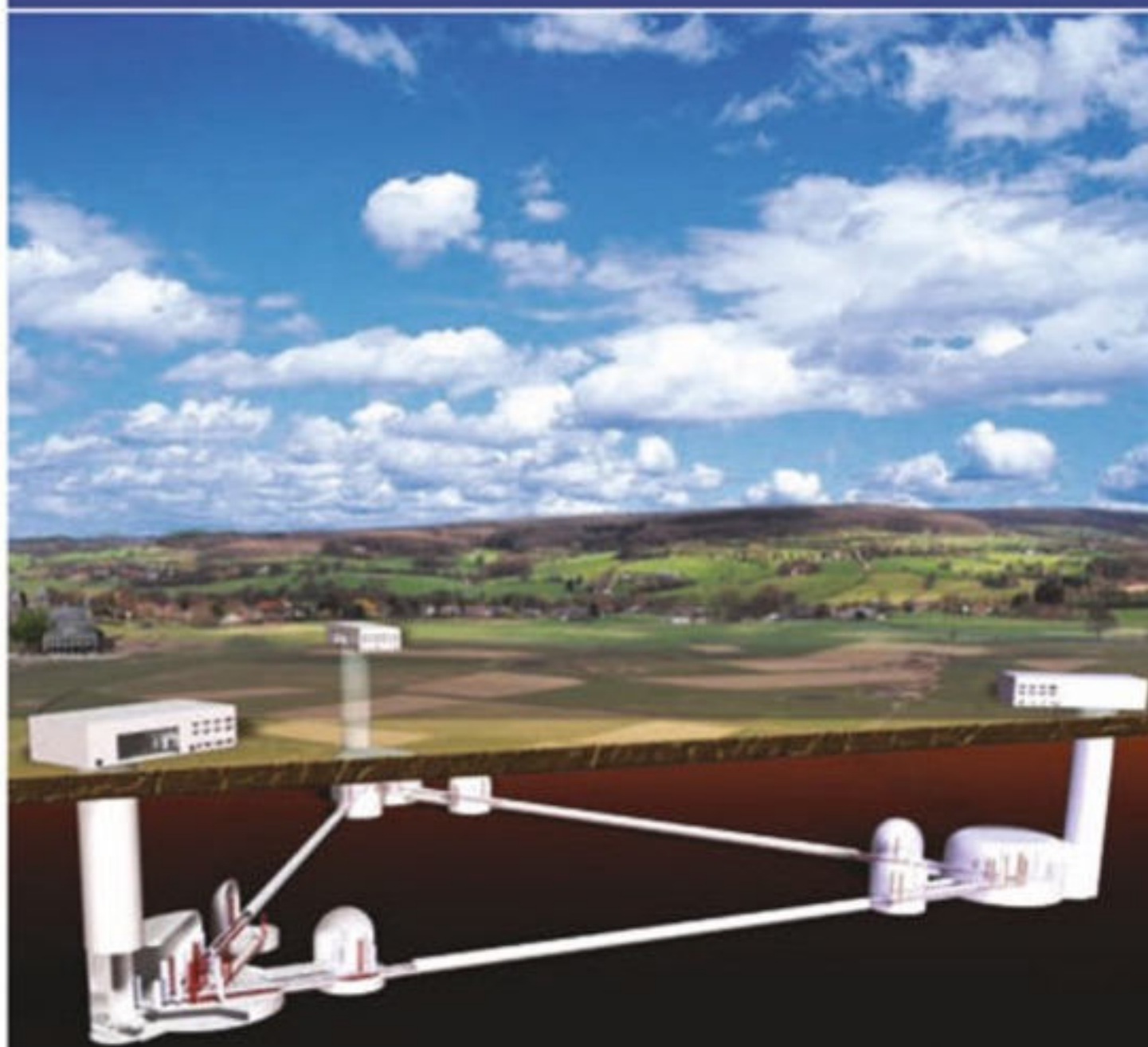
ALMA is designed to detect 'cool' objects, which emit most of their energy in the millimetre wavelength range. It will pick out the dust created by exploding stars in the very earliest phases of the Universe and peer through dense gas clouds to catch stars and planets in the act of formation.



Number of dishes	66
Diameter of array	16km
Location	Atacama Desert, Chile
Altitude	5,000m
Cost	£812m (\$1.3b)
Completion date	2013



EINSTEIN TELESCOPE



Number of tunnels	3
Length of tunnel	10km
Location	Europe
Altitude	-100m (underground)
Cost	£714m (€827m)
Completion date	2025

Almost a century ago, Albert Einstein predicted that when black holes collide, they send out ripples in the very fabric of the Universe (space-time). But so far, scientists have failed to detect these 'gravitational waves'. There is indirect evidence that they exist, but the Einstein Telescope (ET) is an ambitious plan to finally find them.

A passing gravitational wave would stretch and shrink space. Gravitational wave detectors, unlike telescopes that detect light, would therefore look for the minute changes in the distances between objects. Typically, the amount of shrinking and stretching would be about a billionth the size of an atom.

The challenge is to isolate the ET from vibrations caused by road traffic and other sources. To do that, it will be built at least 100m underground. The design shows laser beams being sent down three 10km-long tunnels connected in a triangle. Laser pulses will measure the length of the tunnels at phenomenally high precision: it will be 100 times more sensitive than existing instruments. Even so, ET will still only be able to detect the very biggest gravitational waves. Such huge disturbances in space-time are thought to arise from highly energetic events. Colliding black holes, exploding stars (supernovae) and the merger of neutron stars (extremely dense remnants of massive stars) are the type of phenomena the ET is likely to detect.

Some 15 sites, mostly on mainland Europe, have been identified but the design and funding mean it's unlikely to be operational before the middle of next decade.

SKA (Square Kilometre Array)



Number of antennas	4,000
Diameter of array	3,000km
Location	Karoo, South Africa or Boolardy, Australia
Altitude	1,000m (South Africa) or 460m (Australia)
Cost	£1.25b (\$2b)
Completion date	2022

Radio waves from space are extremely weak. Since they were first turned to the heavens just 80 years ago, the total amount of energy received by all the world's radio telescopes totals less than that used by a 1 Watt light bulb in a second – you use a million times this energy every time you boil a kettle.

To collect as much of these weak signals as possible, radio astronomers have always built large telescopes. But now they want to build the most powerful telescope in history: the Square Kilometer Array (SKA). As its name suggests, the SKA will have a collecting area of one square kilometre (a million square metres), pushing sensitivity to 50 times what is currently available.

According to Professor Richard Schilizzi, director of the SKA Project Development Office in Manchester, the telescope will revolutionise radio astronomy. "The SKA will be able to pick up faint cosmic whispers from the first stars and galaxies formed after the Big Bang. It'll be capable of detecting gravitational waves created by merging massive black holes and could help unravel the mysteries of dark energy."

Like ALMA, the SKA will be an interferometer. It will consist of up to 4,000 separate radio antennas spread over an area about 3,000km across. And all these elements will be linked by fibres to a hugely powerful supercomputer that will create images.

The innovative design of the SKA is extremely demanding – so demanding in fact that the technology to build it doesn't yet exist. The huge computing power required, the transmission of enormous amounts of data at high speed over vast distances, and the complex electronics are all yet to be developed.

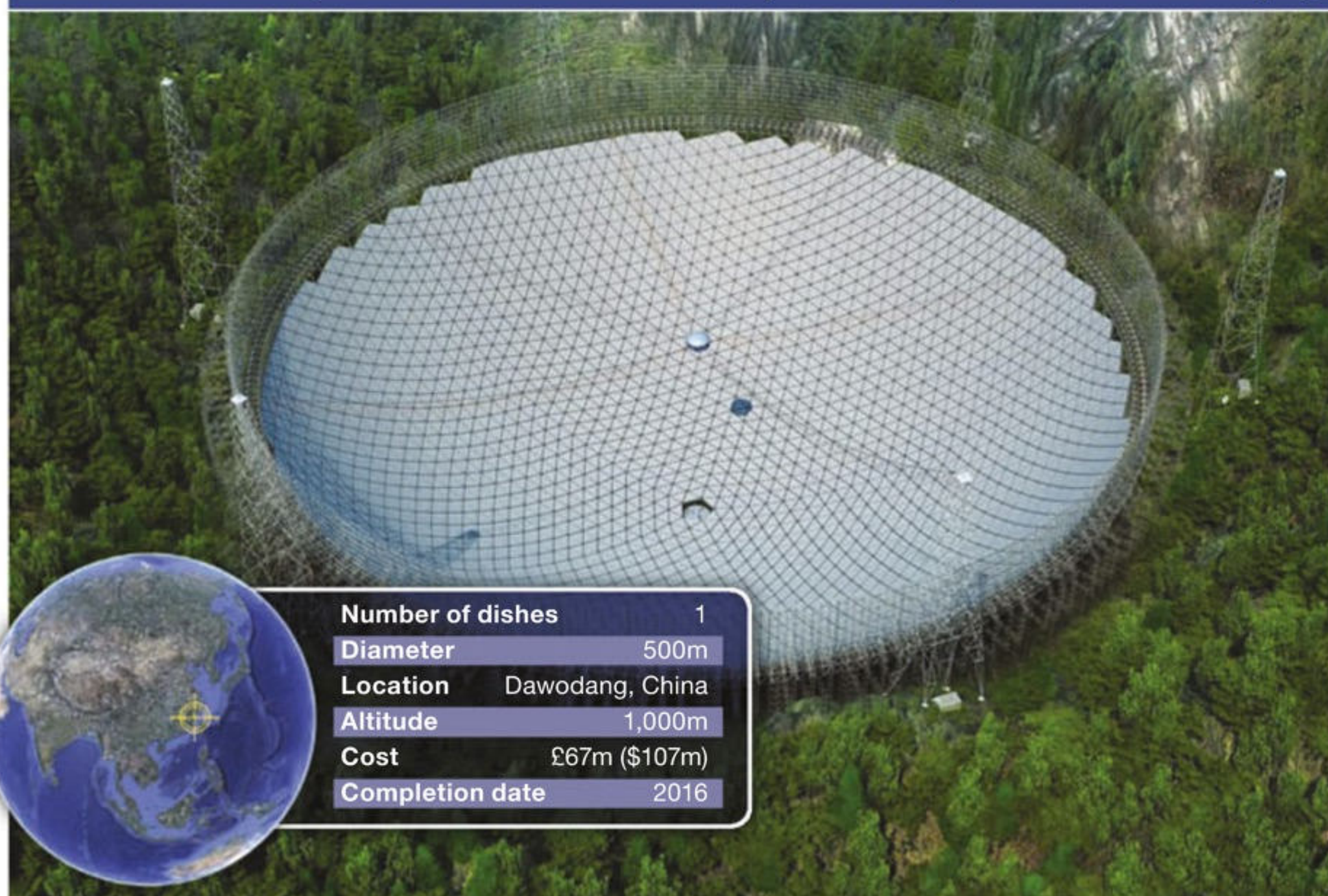
But the SKA designers are gambling on these developments being realised by the time they come to actually building the telescope. The location of the SKA, due to be decided over the next few months, will be either southern Africa or western Australia, far removed from human-generated radio interference.





The SKA's 3,000 15m dishes (top) and around 1,000 antennas will be listening for radio waves from the furthest reaches of the Universe

FAST (Five-hundred-meter Aperture Spherical Telescope)



Number of dishes	1
Diameter	500m
Location	Dawodang, China
Altitude	1,000m
Cost	£67m (\$107m)
Completion date	2016

What will be the largest single-dish telescope on Earth is currently under construction in Guizhou province, China. Known as the Five-hundred-meter Aperture Spherical Telescope (FAST), this huge radio antenna is being built in a natural depression in the ground, much like the famous Arecibo dish in the jungle of Puerto Rico. With a collecting

area equal to 30 football pitches, FAST far surpasses Arecibo in size. It will be able to see three times further into space and survey the sky 10 times faster, and is expected to be fully operational by 2016.

Astronomers hope FAST's great sensitivity will complement the work of the SKA when it comes online in the early 2020s. The telescope

will help in the hunt for dark matter and search out the faint signals of Jupiter-sized planets in other star systems. It will also be used to find new 'pulsars', the extremely dense, rapidly spinning cores of dead stars, as well as scrutinise nearby star systems for unnatural radio signals, hoping to see signs of extraterrestrial civilization.

Stargazing LIVE

16-18 January, 8pm-9pm

Professor Brian Cox and comedian Dara Ó Briain are back for another three-night celebration of amateur astronomy. The presenters will be joined by celebrity guests at the University of Manchester's Jodrell Bank observatory in Cheshire. Over three episodes, they'll point their telescopes skywards to focus on the Moon, the Milky Way and planets in other galaxies. A half-hour 'Extra' programme will follow each show, with experts answering questions from viewers. Hundreds of events will also take place across the country – visit www.bbc.co.uk/stargazing to find out about them and check out the January issue of *Sky At Night Magazine* for an exclusive interview with Brian Cox.



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The secrets of DUST

Scientists are learning surprising new things about the grey stuff that's all around us. **Jo Carlowe** reveals what dust is made of, and why it's important

What is dust? The answer seems obvious: it's the grey, powdery stuff you get when running your finger along a skirting board or opening an old book. Dust also coats our computer screens in a thin film and forms beneath our mattresses. It even gets mentioned when we die: ashes to ashes, dust to dust.

Dust is everywhere – in our homes, in the atmosphere, even in space. Everything we do and everywhere we go impacts on dust and its composition. Like the character Pig-Pen from the *Peanuts*

cartoons, we're even accompanied by our own personal dust clouds.

No wonder, then, that dust is considered important enough for some scientists to spend their lives studying it. "Anything that is half hidden is fascinating to us," says Hannah Holmes, author of *The Secret Life of Dust*. "Dust is visible, but just barely. It's human nature to poke and prod at things we can't fully understand."

Dyson, maker of the bag-less vacuum cleaner, has set up an entire microbiology lab dedicated to the study of dust. In Dyson's ►

► lab, 'dustologists' farm two colonies of dust mites – a European species and an American one – and feed the little critters a mixture of yeast, wheat germ and dog biscuits. The mites are kept in their favourite conditions of 25°C and +75 per cent relative humidity to encourage them to thrive.

When you hear that there are around 10,000 dust mites living in your bed, you quickly realise how important it is to find efficient ways to get rid of them. "We're constantly researching new solutions to the problem of dust mite faeces causing allergic reactions," explains Dyson microbiologist Josephine Hoenderkamp, who works with the company's engineers to research and develop the best levels of filtration in Dyson vacuum cleaners.

Meanwhile, a team of chemists led by James Coe at Ohio State University are building up a 'dust library' to catalogue the contents of the grey stuff. According to Professor Coe, the relevance of dust to public health is huge. "It's organic airborne particulates that are linked to disease,

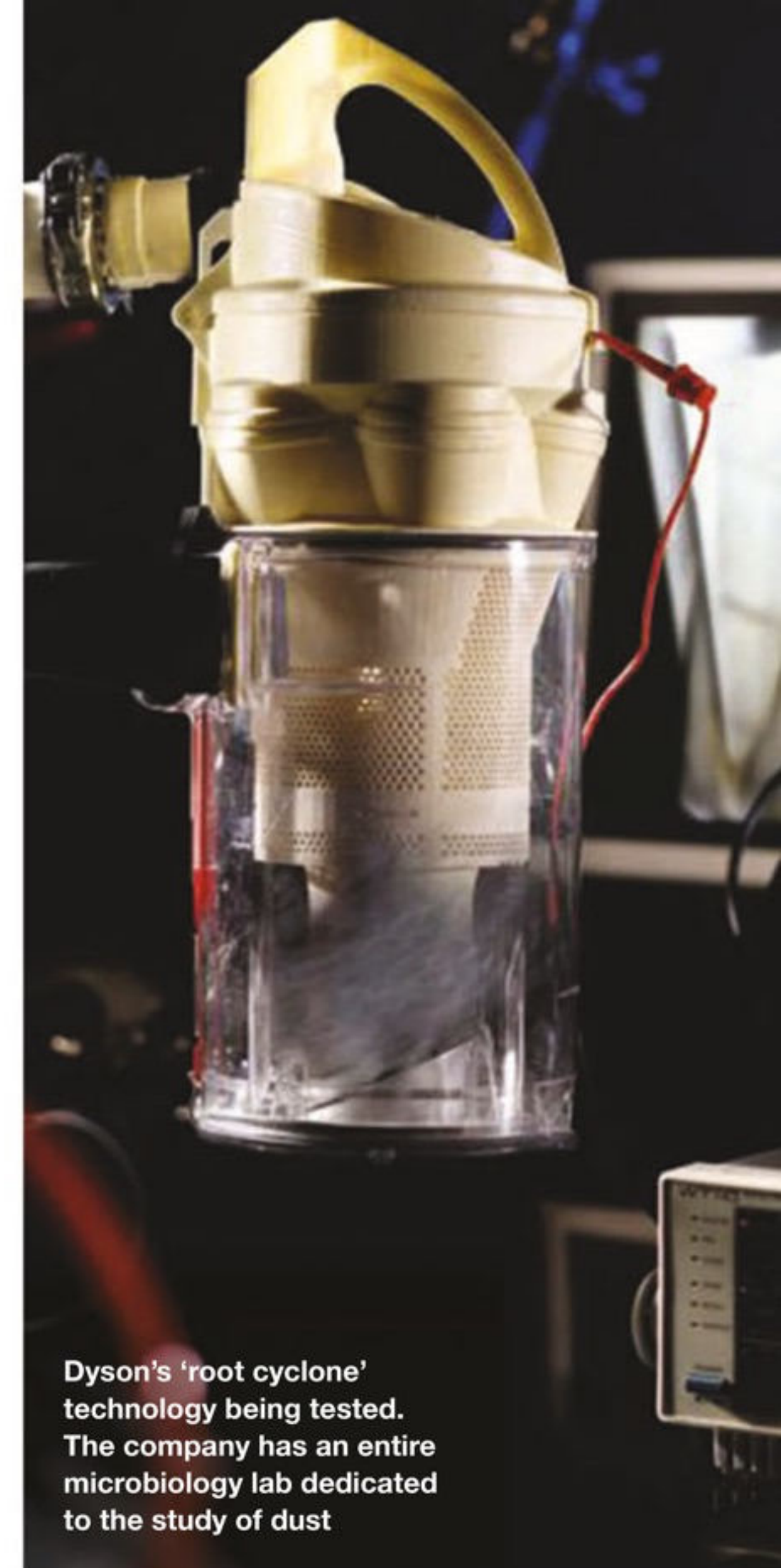
such as silica dust from mining, which causes lung disease," he says. "By identifying the components, one can direct diagnostics to those components and better identify problems."

While testing out a new sensor in their laboratory, the team found they had isolated 63 unique dust particles. They set to work measuring the composition of each particle and published their findings in the *Journal of Physical Chemistry*. They now plan to study many more particles, taken from areas such as car parks and smoking lounges, and break these down by composition too. The idea is to identify the critical components of the dust they encounter. Working out the composition of dust from specific locations and linking this to data on mortality could ultimately lead to improved diagnosis of some respiratory diseases and other conditions, resulting in better-targeted treatment.

Different dusts

Clearly the study of dust is not solely for curiosity, but for the good of public

The Sahara desert may yield as much as a billion tonnes of dust a year



Dyson's 'root cyclone' technology being tested. The company has an entire microbiology lab dedicated to the study of dust

health. So what can dustologists tell us so far? For one thing, they have a pretty good idea of what it's made of (see opposite). Dust is the matter that comes from everything around us – including ourselves, our pets, plants, furniture and clothes. In fact, everything we do leaves an imprint on the dust around us. "The particulate matter counts change by the minute, they change when people are cooking and with day or night," says Coe.

The seasons play a part too, with airborne particles settling on surfaces after blowing in or getting carried into our homes. "Natural events, like the springtime release of pollen or the autumn bloom of fungi in fallen leaves, lend a seasonal flavour to dust," says Hannah Holmes, adding that different neighbourhoods can have different types of dust. "Whatever is falling apart in your neck of the woods determines what the wind will be carrying. Seaside towns will have more particles of salt in their dust, while farming villages will feature more plant parts and even bits of manure."

Different countries also produce different amounts of dust. If generating dust were a competition, the nation to beat would probably be Chad, home to an enormous dry lake that launches streams of dust that can be seen from space. Another challenger for the title



The European house dust mite, *Dermatophagoides pteronyssinus*



of dustiest place on Earth is the Sahara desert, which may yield as much as a billion tonnes a year – dust from the Sahara can probably be found under every bed in the world.

Detecting the movement of dust also offers a wealth of geographical information. “There are interesting connections between places,” says James Coe. “Much soil in the Caribbean islands blew across the ocean from the Sahara desert; we in the US get dust particles from the Gobi desert.”

He adds that small, particulate matter can travel long distances around the globe. Larger particles fall out of dust more easily, indicating ►



In seaside towns, dust will contain particles of sand and sea salt

WHAT'S IN DUST?

HOUSEHOLD DUST

The composition of household dust will vary from place to place, but it mostly consists of organic matter that naturally comes off people, pets, plants and anything else that lives in our homes. The main components include human skin flakes, fibres from plants, clothing and furnishings, dust mite faeces, smoke and oil droplets from cooking, plus tracked-in soil brought in on our shoes and airborne particles blown in from outdoors. The dust under your mattress is lighter than that on your carpet because it contains more human skin flakes. Our hobbies add a personal signature to house dust: woodworkers have pine dust in their homes, cooks make savoury dust, while readers produce papery particles. Within household dust there's also an entire ecosystem made up of dust mites and book lice, plus predatory pseudo-scorpions that feed on them.

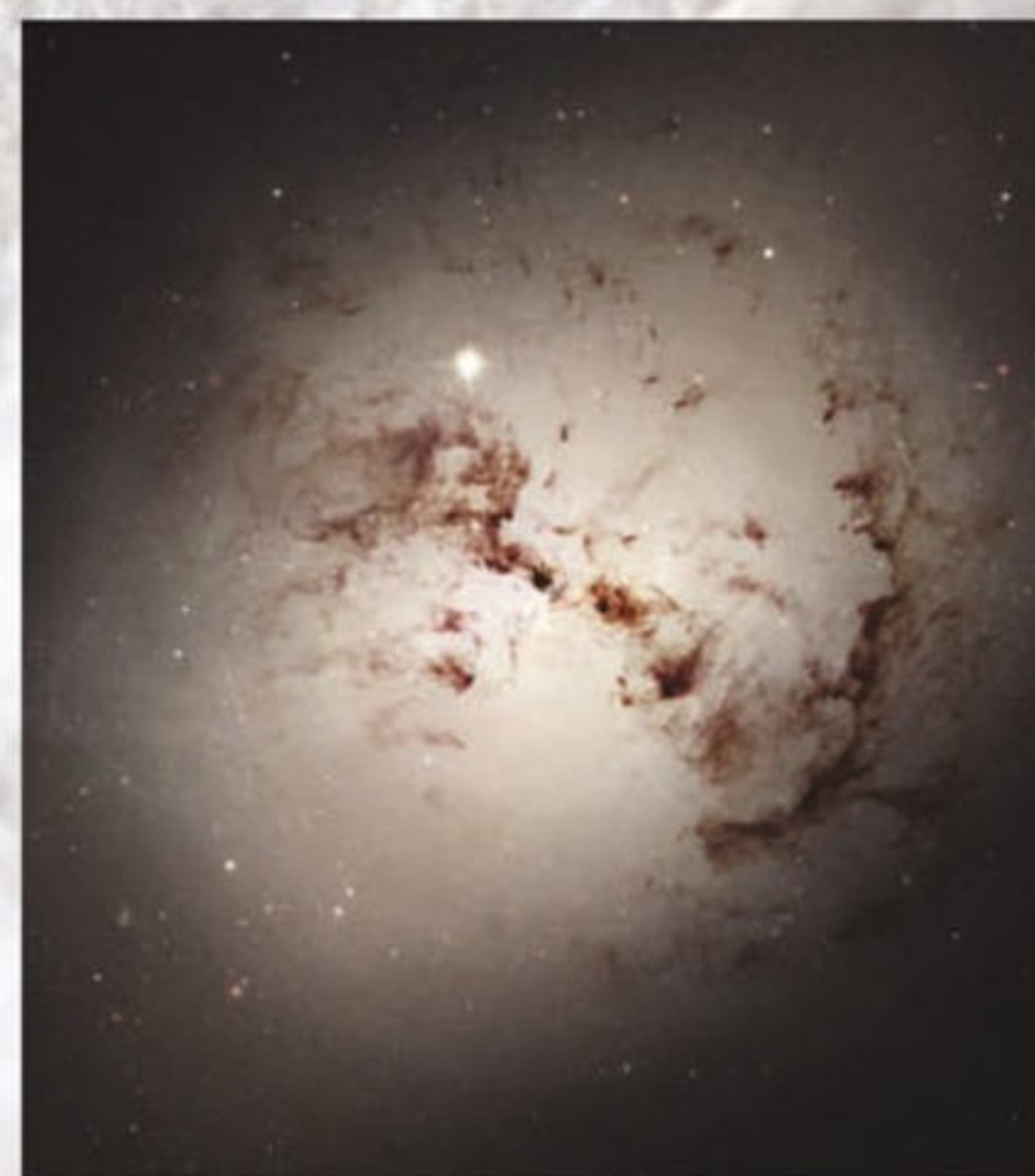


ATMOSPHERIC DUST

Sand particles and dust kicked up from the roads make up a large proportion of air pollution. The latter consists of deposits from car exhaust, tyres, brake-disc wear and construction sites. Chemistry professor James Coe has analysed atmospheric dust particles and found that 63 per cent contained organic matter, quartz was present in 54 per cent and gypsum in 22 per cent. This shows that such dust consists of agricultural chemicals, building materials, soil, smoke particles and sulphur compounds from coal. According to dustologist Hannah Holmes, human activities have doubled the amount of dust in the air: “The Earth's surface is in a state of decay. Rocks erode, plants thrash in the wind, sand blows around, butterflies knock scales off their wings. Human industry speeds up the process.”

COSMIC DUST

Our planet was made from cosmic dust (also called space dust), so it's chemically quite familiar to us. This dust is rich in quartz and spiked with plenty of other earthy minerals, including exotic gems such as diamond, sapphire and peridot. Physically, cosmic dust looks like popcorn. In the deep freeze of space, these tiny dust bunnies incorporate ices along with the minerals. But if cosmic dust gets too near the sun, or encounters the Earth's atmosphere, these ices vaporise, leaving a fluffy cluster of grains. Where scientists have collected cosmic dust on Earth, it has first passed through the atmosphere at high speed, causing it to melt and take on the appearance of tiny marbles. Cosmic dust will also vary in composition according to its astronomical location, and may contain dust from comets, asteroids and the Kuiper belt.



HARMFUL TO HEALTH?

Dust in itself isn't harmful, says environmental health expert Paloma Beamer of the University of Arizona – it's its size and make-up that render it hazardous. "If the dust is small enough to be inhaled, the particles can cause damage to the lung tissue, depending upon their size, shape and number," Professor Beamer explains.

A study from Johns Hopkins University in Baltimore found higher levels of hospital admissions in people exposed to dust particles measuring 2.5 micrometres (microns) or less. To put this in context, red blood cells are around 10 microns.

The other issue is composition. Marjorie Hoy, professor of biological control at the University of Florida, says that dust can contain fungi, mites and dead insects like cockroaches. "Dust mites produce faecal pellets that contain proteins that cause allergic responses in some people." The solution is to 'tame' your dust. Experts recommended removing shoes, vacuuming frequently, covering mattresses in mite-proof covers and reducing relative humidity to under 70 per cent (dehumidifiers can help). Not to mention killing mites by washing bedding in very hot water and freezing stuffed toys.

But dust mites do have a function. Dustologist Hannah Holmes calls them "our domestic cleaning crew" tasked with slurping up skin flakes. And some scientists advocate the immuno-surveillance hypothesis, which suggests that allergies protect us from other conditions. Danish researchers recently found that people who react to skin irritants may be less likely to develop some cancers. The body falsely believes it is under attack, so primes the immune system to fight off more serious threats. Whether the same holds true for other allergens, such as dust mites, is unclear.

There's also the hygiene hypothesis, the idea that our immune systems can no longer distinguish between harmful and harmless micro-organisms because we live in over-sterile conditions. Support comes from Munich University, which shows lower risk of allergies among farm kids, presumably due to their early contact with livestock and fodder. "Our immune systems evolved to expect an assault of germs and to carry on," says Holmes. "Ironically, it appears that we've won the battle against dirt, and thereby lost the war."



ALAMY X2, NASA



The Bodele Depression in Chad – possibly the single biggest source of dust in the world

► local sources. "The five-micron particles that my group studies are likely to have more local contributions than smaller, fine particulate matter."

Dry, windy conditions are excellent for distributing dust, although Hannah Holmes notes that you're also likely to bring it into your home if your shoes are damp, sticky or muddy. It's not surprising to learn that the Japanese, who have a culture of taking off their shoes prior to entering their homes, have far less road dust indoors.

Josephine Hoenderkamp says Dyson actually produces slightly different vacuum cleaners to suck up Japanese dust. "It is made up of smaller particles, so for Japan we develop specific technology to tackle the unique dust particle make-up."

At the University of Arizona, dustologists led by environmental health expert Paloma Beamer are looking at how dust brought in from outside can impact our well-being. It follows a study from a few years ago,

in which Beamer's team found that around 60 per cent of arsenic and lead in house dust was probably present due to outdoor air particles entering the home and settling, rather than from soil 'tracked in' on shoes.

Dust clearly holds clues to just about every aspect of our lives. If a team of CSI-type investigators were sent into your home, the dust alone would tell them where you live, your job and hobbies, the season and even the time of the day. All this information comes from the grey powdery stuff all around us – something to remember the next time you do the vacuuming. ■

Jo Carlowe is a freelance journalist based in London

FIND OUT MORE

House dust mite information
www.housedustmite.com

The Secret Life Of Dust
Hannah Holmes (Wiley, 2001).

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Q&A

Your questions answered

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What causes spontaneous human combustion?

Spontaneous Human Combustion is so named because the victim is found burned to ash, without much fire damage to the surroundings or any obvious source of ignition. It's very rare and victims are usually elderly and living alone.

Many have assumed that only supernatural or exotic forces could explain the way an undamaged leg is often found, with the rest of the body completely burned. But it's likely that a more down-to-Earth process, called the 'wick effect', is at work. The victim dies first, from a heart attack, stroke

or from a fall. A dropped cigarette or spark from a nearby fire then causes their clothing to smoulder and ignite. As the clothes slowly burn, the heat melts the fat under the skin and the carbonised fabric draws it up like a candlewick and burns it.

Experiments performed with a pig carcass wrapped in a blanket have shown that it will burn with a gentle, steady flame that heats the body to 800°C and lasts for seven or more hours. Unclothed flesh can escape unburned but the rest of the body is completely rendered down. **LV**



100,000km

The total length of blood vessels in the human body

Send us your questions

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ON THE
PODCAST

Could we terraform Mars or Venus?

SCOTT LLOYD, BY EMAIL

Mars is too cold and has an atmosphere that's too thin. If we used CFCs, which are powerful greenhouse gases, it would take about 39 million tonnes to raise the temperature enough to melt the CO₂ glaciers at the poles. Firing enough rockets to transport compressed CFCs to Mars isn't practical but it might be possible to manufacture them locally from Martian minerals.

Venus has the opposite problem – it's 460°C at the surface and 93 times the atmospheric pressure of Earth. To lower the pressure you could bombard the surface with refined magnesium to react with the CO₂ atmosphere and create magnesium carbonate rocks. But you would need five hundred thousand trillion tonnes of magnesium to remove enough CO₂ to bring the greenhouse effect under control.

And you'd still need to add oxygen to both planets. There isn't enough water on either to make splitting it into oxygen and hydrogen practical. You could transport one of Saturn's ice moons but, like every other aspect of terraforming, it would be an absolutely mammoth undertaking. **LV**

The experts



SUSAN BLACKMORE

Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*



ROBERT MATTHEWS

After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University



GARETH MITCHELL

Starting out as a broadcast engineer, Gareth now writes and presents *Digital Planet* on the BBC World Service



LUIS VILLAZON

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach the Ground*

Why are there no blue foods?



Blue is a difficult pigment to make in nature. Blue colours are associated with alkaline chemistry and most plants and animals have a slightly acidic metabolism. The few plants that have blue flowers confine the pigment to the petals and often fade to purple or pink at different times or in acid soils. Blueberries are blue in name only. They're actually purple or indigo but a white powdery coating makes them appear blue when ripe. Blue colouration in animals is achieved with tiny scales that scatter light into the blue part of the spectrum (iridescence) rather than pigment. Because blue is rare in nature, we've evolved to find it unappetising and so there's a selective pressure that favours red fruit. **LV**

Do oak trees produce acorns every year?

BRIAN ATKINSON, BY EMAIL

There are about 600 species of oak and different species reproduce according to different schedules. The white oaks of Europe and North America, which include the Sessile, or Welsh Oak, produce acorns every summer. But the red, intermediate and cerris oaks are adapted to drier, more southerly climates and their acorns take 18 months to mature so they only produce a new crop every other year. **LV**

Can cows swim?

FILIP DANKO, SLOVAKIA

Yes. Most mammals can swim, including cats that hate water and camels that live in waterless deserts. Although all animals originally evolved from aquatic creatures, some kept the ability to swim while others evolved it again after losing it. The movements needed aren't so different from walking, which may explain why so many mammals can swim. Cows also have considerable body fat to keep them afloat. **SB**



4.7

The magnitude of the earthquake caused by an underground nuclear weapon test conducted by North Korea in 2009

Who names the stars and planets?

FIONA HOWARD, FAREHAM



The International Astronomical Union (IAU) oversees the names of celestial objects. Star naming usually follows catalogues with names like General Catalogue or the Henry Draper Catalogue. The star's name is made up of letters representing the specific catalogue and numbers denoting its position. You end up with names like HD 41004 and GC 28804. Amateur astronomers still know bright stars by their traditional names, such as Vega or Betelgeuse.

Extrasolar planets began to be discovered in the mid 1990s, requiring a whole load of new names. Each new planet is named by its discoverer, subject to approval by an IAU working group. For example, the extrasolar planet Kaohsiung was named by amateur astronomer Tsai Yuan-sheng after his home city. Names can be anything within reason. IAU guidelines prefer nomenclature of a single word. The name should also be decent, non-commercial and sufficiently unlike existing ones. And for all you vain people out there, no, the IAU doesn't sell personalised star or planet names. **GM**

Is the mercury in dental fillings dangerous?

Mercury is undoubtedly neurotoxic, so its use in fillings rightly raises concerns. In 2006, the *Journal Of The American Medical Association* published the first two studies of the health effects in children receiving mercury fillings. Both found that even several years later, those getting the fillings had higher mercury levels – but without any obvious ill effects. This suggests the levels were too low to cause trouble. However, the longer-term effects are still unknown, so for now the jury is still out. **RM**

Can you make money by always betting on favourites?

It seems obvious that the horse or football team with the shortest odds has the best chance of winning, and is thus the best bet. The trouble is that favourites don't always win. In fact, in the 144,000 horse races that ran in the UK between 1991 and 2010, the favourite won just 34 per cent of the time.

That wouldn't be a problem if the odds being offered were good enough to compensate for those losses. But they're not: typically they're less than evens so, in the long run, the money you make when favourites win is outweighed by the amount you lose when they don't. If you'd put £1 on every favourite over those 20 years, you'd have ended up losing around £12,000. **RM**





Will thorium revolutionise nuclear power?

JACKIE MACLEAN, GLASGOW

Ever since the first nuclear reactor was built – in a disused squash court at Chicago University in 1942 – two basic fuels have been used: uranium and plutonium. But they're not the only possibilities, and one alternative currently attracting much interest is thorium.

While not capable of sustaining a chain reaction in its natural state, thorium can be persuaded to do so by bombarding it with neutrons. These are mopped up by the thorium, producing a form of uranium (U-233) that produces the heat needed to generate steam for driving turbines, thus producing power.

As a fuel, thorium certainly has some advantages: it's several times more abundant

than uranium and the reserves are in politically stable nations like Australia and Norway. Thorium reactors also produce less radioactive waste, and it's also much harder to turn into nuclear weapons (which, ironically, is why they haven't been popular to date). The basic reactor design can also be simpler, arguably safer, and it doesn't churn out greenhouse gases. All this helps explain why China decided to launch a programme in 2011 to develop thorium-based nuclear reactors as part of its energy strategy. But nuclear experts warn there's relatively little experience in building thorium reactors, and whether their advantages will be fully realised remains to be seen. **RM**

QUICKFIRE



How many humans have ever lived?

RICHARD O'NEILL, GLASGOW

It's difficult to be very precise because we can't pinpoint when our species first emerged to within even the nearest millennium and we don't have good records for historical birth rates and life expectancy. But most modern estimates put the value at between 100 and 115 billion. That's a big jump from the 1970s, when it was thought that just 6 billion people had ever lived. **LV**

Why does hair grow faster on a mole?

OLIVER LAUFKOTTER

Moles are a form of benign neoplasm. A neoplasm (which means 'new growth' in Greek) is a group of cells that have a mutation in one or more of the genes that regulate cell division. This causes the neoplasm to grow a little faster than the surrounding tissue. Fast-growing skin makes the mole raised, and the hair follicles often grow more rapidly too. **LV**

Why do we cover our mouths when shocked?

DAVID PRYCE MORRIS, BY EMAIL

When you're truly shocked, you don't cover your mouth; you just scream. Covering your mouth seems to be a secondary reaction, when you're trying to moderate your initial response. That might be because you have realised there's no danger or because you don't want to alarm those around you. It probably evolved to avoid spreading unnecessary panic in groups. **LV**

Why is a green screen green?

ANDREW EVERSETT, BY EMAIL

It's a technique called chroma keying, where someone is filmed standing in front of a green screen. Any green colours are digitally filtered out and replaced by the desired video. If the subject wears anything green, the background image fills that in too, giving the impression the person has holes in them. Green is used as it is the least like skin tone. **GM**

DID YOU KNOW?

By area, the Netherlands has more tornadoes than any other country, with twister for every 1,991km² (769 miles²) of land. The US, known for its tornado season, has one per 8,187km² (3,161 miles²).



THINGS YOU THOUGHT YOU KNEW

Does water drain differently below the equator?

The idea that the Earth's rotation causes water to drain down a plughole differently in the northern and southern hemisphere is an enduring one, popularised in shows such as *The Simpsons*. People living on the equator even make money by 'demonstrating' the effect through sleight of hand to gullible tourists.

The Earth's rotation causes a deflection of objects moving across its surface – known as the Coriolis effect. The effect is significant on the large-scale, for example, in the way it affects ocean currents and weather patterns. It makes storms swirl anticlockwise in the Northern hemisphere and clockwise in the Southern hemisphere. However, on the small scale of a sink, the effect is tiny and overridden by factors like the sink's shape, room temperature and currents lingering from when the sink was filled.

Only in a carefully controlled laboratory setting can you expect to see the effect in anything as small as a sink, as demonstrated in 1962 by MIT fluid mechanics expert Ascher Shapiro. Shapiro filled a circular tank 1.8m in diameter and 150mm deep that had a tiny hole drilled in the bottom that could be unplugged from below. He covered the tank with plastic to allow the temperature to stabilise and then left the water to settle for 24 hours. When he pulled out the plug, the water began to swirl in an anticlockwise direction. In 1965, the experiment was repeated at the University of Sydney and the water swirled in a clockwise direction.

So, yes, water does spiral differently in the Southern hemisphere but only under laboratory conditions, and not at home or in tourist traps on the equator.



The bigger the sink, the greater the influence of the coriolis effect

How fast is the Universe expanding?

DAVID SPENCE, BY EMAIL

The expansion of the Universe is unusual in that the further we look, the faster galaxies appear to be racing away from us. This is captured in Hubble's Constant, the standard way of measuring the cosmic expansion.

Analysis of the light from distant stars and galaxies reveals both their speed and distance, and these imply that the cosmic expansion rate is surprisingly sluggish: the speed of recession increases by just 1km/h

for every 13 light-years of distance. As such, we can all but forget about the cosmic expansion on the scale of our Galaxy, where it's overwhelmed by gravity in any case.

Only on the largest scales does the expansion of the Universe start to really get up steam, with the most distant visible galaxies, which lie many billions of light-years away, receding from us at sizeable fractions of the speed of light. **RM**

How fast can a human safely travel?

It's not the speed that's dangerous; it's the sudden stop. In fact, we can't directly perceive speed at all, only acceleration and the relative speed between us and another object. We're travelling at 720,000km/h right now, as our Solar System orbits the centre of the Galaxy.

What is a safe speed depends on the obstacles in your way and the thickness of the medium you're travelling through. Provided you had a spaceship with enough fuel and you could plot a course that avoided any solid objects, it would be quite possible to get within 0.1 per cent of the speed of light. **LV**

DID YOU KNOW?

The largest revolving globe is 12.52m in diameter and weighs 2,540kg. It can be found in a three-storey glass atrium at the headquarters of GPS and digital map manufacturer DeLorme in Maine in the US. It requires two electric motors to power its spin.



When did time zones start?

ALEKSA JANKOVIC, BY EMAIL

Greenwich Mean Time (GMT) was established in 1675 but it was only used as a reference for sailors so they could determine the offset between the local noon and GMT to calculate their longitude position. On land, each town still set its clocks to the local noon, as determined by a sundial. This was quite workable until the invention of the railway, when British train companies needed a standard clock to keep their timetables straight. They adopted GMT in 1847 and it became the legal national time in 1880.

Hourly time zones were proposed by the Canadian Sir Sandford Fleming in 1879, and adopted piecemeal by various navies and governments during the 1920s. China used five time zones within its borders until 1949 but now uses GMT +8 hours throughout and a handful of countries have national times that don't fit into hourly time zones. Afghanistan, for example, is four and a half hours ahead of GMT and Nepal time is GMT +5 hours 45 minutes. **LV**



84.01

The number of years it takes
Uranus to complete one orbit
of the Sun

What is the fuel consumption of an ocean liner?

R J WEST, CAMBRIDGESHIRE

An ocean liner burns about 120 litres of fuel per kilometre. That compares to your car that gets through, say, 0.06 litres per kilometre. A jumbo jet consumes 12 litres per kilometre. But with 500 passengers, the jet can fly each person 42km on a litre of fuel. The ship manages 25km per litre per passenger, assuming 3,000 on board. A family car carries four passengers 67km per litre. **GM**

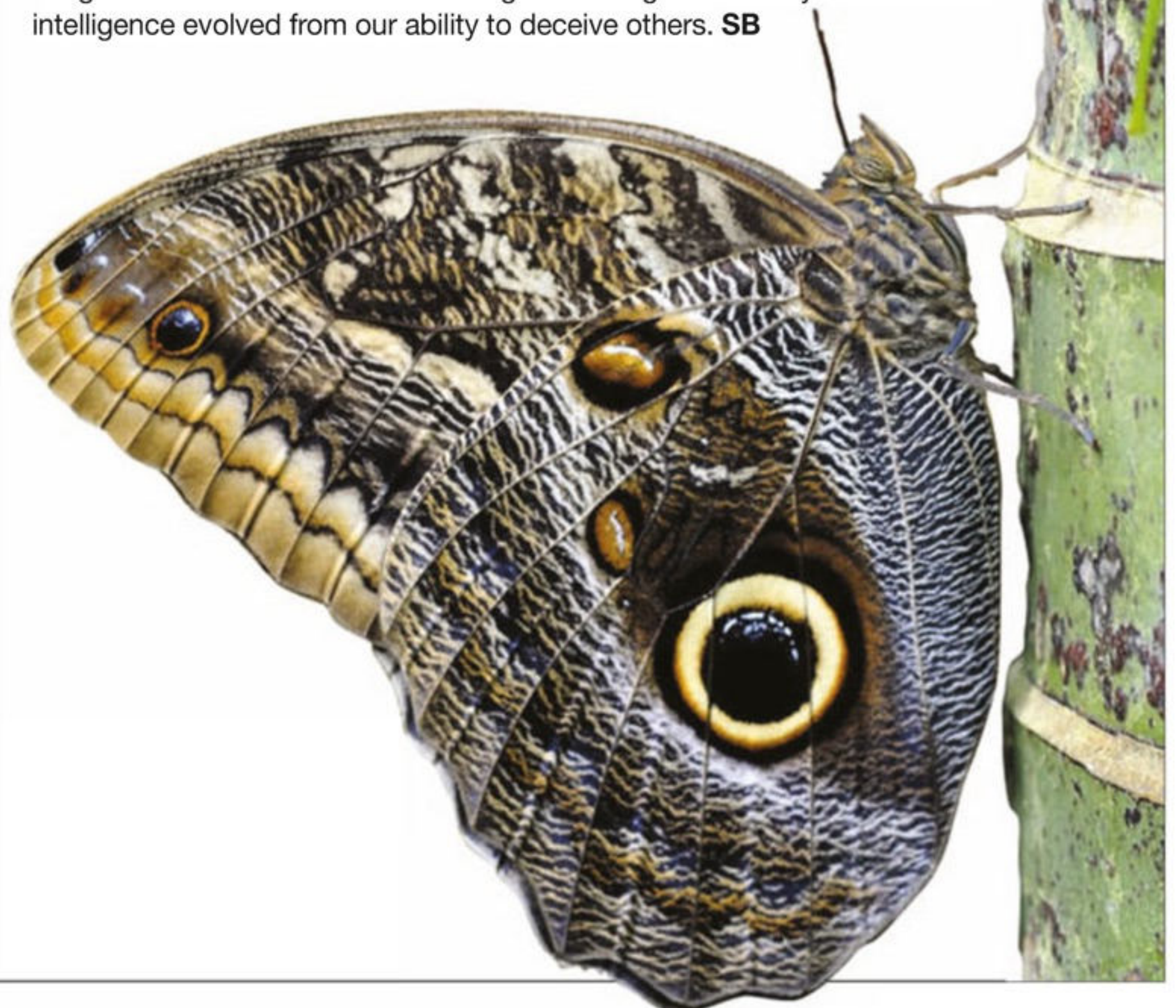


Do animals ever lie?

GEORGIOS AGELAKOS, BY EMAIL

Not exactly, but many animals deceive each other. A butterfly with large eye-spots on its wings appears much larger and more dangerous than it is: a stick insect 'pretends' to be an inedible twig. These kinds of deception are hard-wired, as are some behaviours, such as when ground-nesting birds lure predators away from chicks in their nest by feigning a broken wing.

Closer to lying are the deceptive behaviours of many primates. Monkeys and baboons will distract the attention of others to snatch food, or wait until fights break out to grab a chance to mate. Chimpanzees are even more devious, and in experiments have been shown to take circuitous routes to get to food so that the observers can't see them. Real deception like this requires considerable intelligence, possibly including the ability to imagine what another animal is seeing or thinking. One theory is that human intelligence evolved from our ability to deceive others. **SB**



How many satellites are there?

BEN ROSS, FAREHAM

The Space Surveillance Network (SSN), part of the US Strategic Command, tracks space objects and has clocked nearly 25,000 items since it was founded during the Cold War. At present it has a catalogue of over 22,000 objects. These can be anything from the tiniest piece of debris a few centimetres in size, right up to large communications satellites and the International Space Station.

Estimates vary but it's thought there are 2,500 to 3,000 operational satellites currently in orbit. The SSN monitors the Earth's backyard through a global network of sensors and radar stations. It raises the alarm if any object appears to pose a threat to other spacecraft or the Earth. It also predicts where and when an object is expected to re-enter the atmosphere. **GM**

What would happen if Earth stopped spinning?

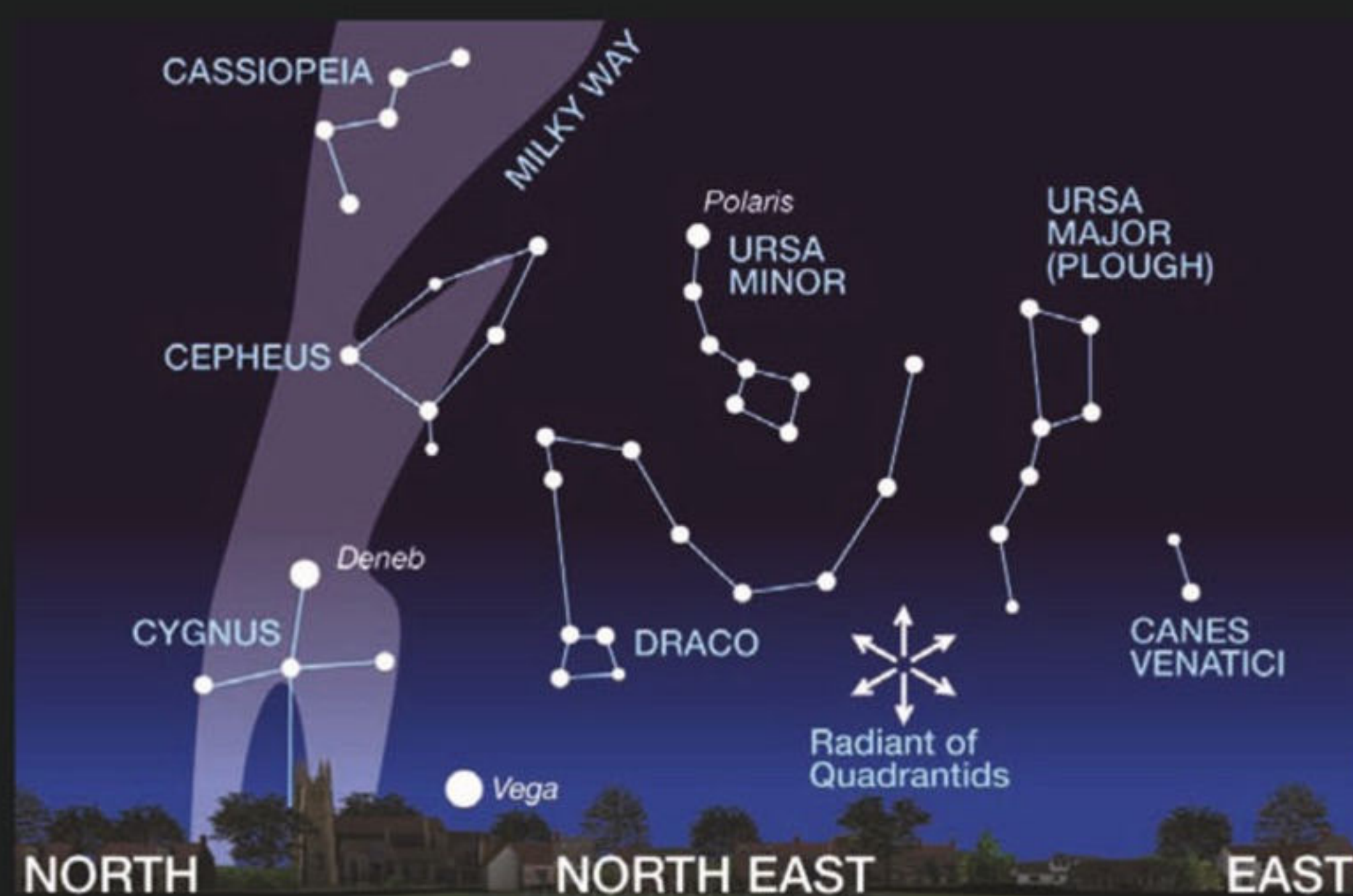
UMANG RAJBHANDARI, BY EMAIL

Well, despite what you might think, we won't all be flung off into space. It would mean the loss of the 24-hour cycle of day and night. The end of the daily grind would have another spectacular effect on Earth: the complete redrawing of the world. With the centrifugal effect of rotation gone, the oceans would flow to where gravity is strongest: over the poles. That would lead to a vast continent appearing around the Equator, bounded north and south by sea. **RM**

25 million

The number of people killed by the bubonic plague in the mid-14th century

Skywatching with astronomy gurus Heather Couper and Nigel Henbest



Look northeast in January at around 10pm and you might spot a Quadrantid meteor, although it's best to wait until the Moon has set. Ursa Major, also called the Plough, is prominent too

What can I see in January?

● 3-4 January north, visible all night

It's the maximum of the Quadrantid meteor shower. Particles from the old comet 2003 EH1 stream into Earth's atmosphere, burning up at a height of around 80km. If you're up to it, go meteor watching after 3.30am, when the Moon has set.

● 5 January 0.32am

The Earth is at perihelion – the closest point to the Sun in its elliptical orbit. It now lies a mere 147,097,207km away from our local star. At the furthest point on its orbital path – known as its aphelion – Earth is 152,098,232km away from the Sun.

● 26 January, southwest, 7 pm

The brilliant planet Venus nuzzles up to the crescent Moon tonight. The glorious queen of the night will be a permanent fixture in our skies until May.

Watch *The Sky At Night* on BBC One. Check radiotimes.com for details

BBC one



Is it possible to build immunity to electric shocks?

SAM PALMER, BY EMAIL

An electric shock is just another kind of stimulus and if you are regularly exposed to the same stimulus, your nervous system will eventually respond less strongly to it. But this desensitisation only really applies to mild stimuli. You can't 'train' yourself starting with mild shocks and eventually work up to the point where you can safely stick your fingers in a 13-amp socket. **LV**



How are sat-nav voices programmed?

Initially, voices on sat-nav and other talking gadgets were synthesised. But actors and celebrities have now lent their voices to the devices, to replace the robotic ones. In some systems, the actor is recorded saying all likely words and phrases. Each recording is turned into an audio file that's triggered by the software on the machine. But that only works if the range of possible voice prompts is quite limited. More elaborate systems record dozens or even hundreds of individual sounds, or phonemes. These are digitally stitched together to form coherent words, having been processed to reproduce the correct intonation, duration and emphasis. **GM**

DID YOU KNOW?

In 1979 Robert Williams became the first person to be killed by a robot. He received an accidental blow to the head from a production line robot in a Ford Motor Company casting plant in Michigan, USA.



Why can't we move our ears?

STEPHANIE TESTAFERRATA, MALTA

We can, if only rather feebly. Some people can move one ear, both ears or even move them independently, and there is some evidence for a hereditary link. If you can't, there are ways of learning, including practising special movements and artificially stimulating the muscles around your ear to learn what the movements feel like.

Even so, humans can't move their ears as much as many other animals, probably because we depend so heavily on sight and can move our heads, rather than just our ears, when we need to find out where a sound is coming from. **SB**

QUICKFIRE

Why do giraffes have such long necks?

A famous 'Just So Story' says they grew longer necks to reach the highest leaves but this is unlikely because giraffes mostly feed on low bushes. The more likely explanation is sexual selection. Female giraffes find long necks sexy and males compete for females by fighting with their necks and bashing their heads together. The successful ones then pass on their genes for having a long neck. **SB**



When are you contagious with a cold virus?

Contrary to popular belief, there's no single cold virus; the notorious symptoms are triggered by scores of different kinds of viruses, each with their own characteristics. As a result it's possible to be contagious up to several days before you show any symptoms alerting others to the risk you pose. Once the runny nose and the rest appear, you're a health issue to others for up to a week. **RM**

NEXTMONTH

Can a deaf schizophrenic hear voices?

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Do fish die when lightning strikes the ocean?

How tall can people grow?

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If you can't wait until then, check out the **Q&A** archive
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The Guide

Everything for the clued-up consumer

Don't miss

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FULL TILT

Presenters Kate Humble and Dr Helen Czerski talk to Daniel Bennett about their new series *23 Degrees*

Twenty-three degrees is the angle at which the Earth's axis is tilted. It might not seem like much but this lean creates the seasons as we know them. In the summer, the UK's portion of the northern hemisphere faces the Sun at a more direct angle than in the winter months, so we enjoy the warming effect of the Sun's rays to a greater extent.

It's this relationship with the Sun that presenters Kate Humble and Dr Helen Czerski explore in *23 Degrees*. The pair chase extraordinary weather patterns around the world over the course of one solar orbit (one year) to demonstrate how the Earth's tilt, orbit and spin influence its weather.

"We're looking at a year in the life of the love affair between the Earth and the Sun," says Kate. "We started filming on 3 January 2011, which was the perihelion: the day when Earth is closest to the Sun. Although, frankly, you could have fooled me as we were in Rannoch Moor, Scotland, fighting against 128km/h (80mph) winds in a blizzard while trying to explain that this was our closest to the Sun."

Unfortunately for Kate, the filming conditions didn't seem to get much better from there. "Later that month we filmed in a place called Yellowknife in the Canadian Arctic where it was -40°C. I've never been in a temperature that cold. It literally freezes everything: your eyelashes, your hair, even the camera. It hurt to breathe. We boiled a kettle full of

water, threw it in to the air and it instantly turned into a sort of fine mist of snow."

Having to rely on the seemingly fickle whims of the weather made *23 Degrees* a uniquely tricky series to film. "It's a mug's game," says Helen, who is also a physics research fellow at the University of Southampton. "You have no control at all. We knew about hurricane Irene but the scientists told us it wouldn't be very big and would be off-shore. So instead of the east coast of America, we went to Mexico, where we had to wait three weeks for something to show up."

The production team's patience did pay off: the show captured stunning footage of hurricanes, monsoons, tornadoes and much more besides. But, for Helen, one image stood out.

"We came over the horizon and we were shocked. We saw this tornado reaching right up into the sky. It was so striking because we, as humans, know the clouds are high but most of us have never seen anything that ever joins them to the ground. The sense of scale was overwhelming and seeing it changed my perspective."

23 Degrees will be shown in January on BBC Two. Check www.radiotimes.com for details

Daniel Bennett is Reviews Editor of *Focus*

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The Review Squad

Gwynne Dixon

The deputy editor of Totalvideo games.com casts his critical eye over OnLive, the UK's first cloud gaming service before giving us his first impressions on p84.



James Witts

The editor of *220 Triathlon* magazine has spent years putting all sorts of fitness gadgets through their paces. He tests five of the latest training devices on p88.



Daniel Bennett

Dan is *Focus*'s reviews editor and our resident gadget expert. He's spent the last few weeks dutifully testing the latest generation of smartphones.



Spencer Kelly

The presenter of BBC's *Click* also moonlights as *Focus* magazine's Tech Doc. He's got a diagnosis for every digital disorder. This month: how to rejuvenate your dead tech.



Bill Thompson

Bill has been involved with the net since 1984 and helped set up *The Guardian*'s website. He wonders whether programming should be taught in schools on p101.



CLOUD GAMING

As OnLive, the world's first cloud gaming service, launches in the UK, Gwynne Dixon puts it to the test...

What is cloud gaming?

It's effectively playing games on somebody else's computer – OnLive's in Luxembourg to be precise, which you access via an internet connection. It works because today's broadband connections are fast enough to allow signals from the control pad in your hands, and the feedback from the server, to be sent and received almost instantaneously.

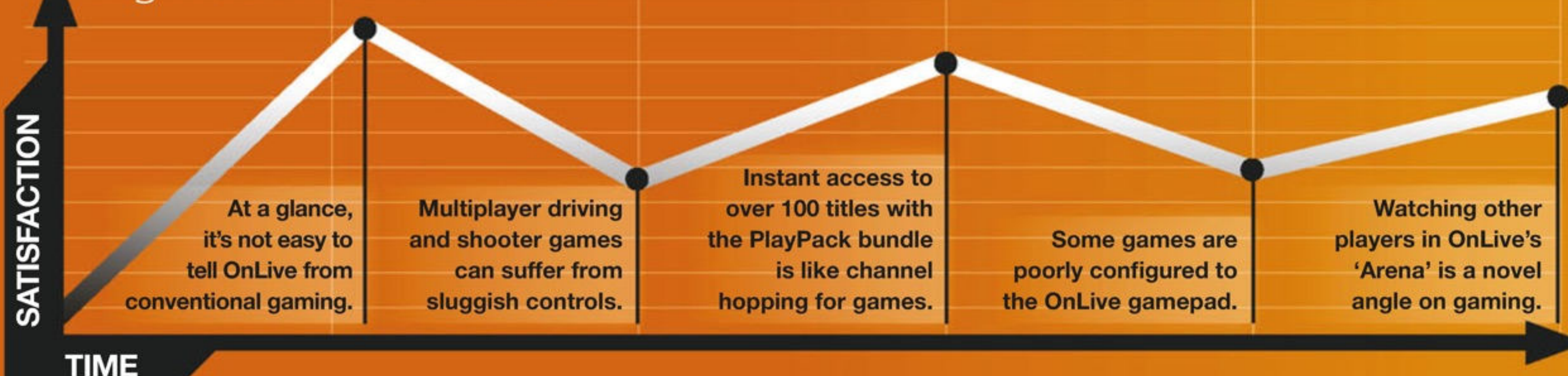
How does it beat consoles?

The biggest attraction is the ability to play the latest blockbuster games without the need for high-end PC hardware or expensive console systems. If you own a Mac, OnLive gives you access to hundreds of games that previously couldn't be played on the machines. The service also puts a large library of titles at your fingertips without having to visit the shops or wait hours for a game to download. OnLive really is as instantaneous as it gets – games will play the moment you've paid for them.

There are also some novel payment options. Alongside simply purchasing the game you want, there's a PlayPack bundle that costs £6.99 a month. For your money you get 30 per cent discounts when you buy the newest games and unlimited access to over 100 games in the growing back-catalogue, potentially saving you a small fortune. And before you hand over the cash for any game, you can spy on other people playing it via the OnLive Arena or try out a free



My week with **ONLIVE**





Watch other gamers in action through the OnLive Arena

30-minute sample for yourself. You can even rent games for a few days at a time.

Do I need a fast web connection?

You'll need a broadband connection of at least two megabits per second (although five megabits per second is recommended), both of which come in below the national average according to Ofcom. The service can then be accessed from either a PC or Mac, or OnLive's own console system, which costs £69.99 and requires an HDTV. While PC users won't need the latest hardware to run OnLive, a dual-core processor and monitor capable of high-definition resolutions are recommended.

What games can I get through OnLive?

At the moment OnLive offers a wide variety of games, from the latest blockbuster titles to a range of independently developed games, as well as an extensive back-catalogue. Notably, the world's two biggest publishers, EA and Activision, are yet to sign up their games libraries to the service, so you can't play *Battlefield 3* or *Call of Duty: Modern Warfare 3*.

Should I buy it?

For laid-back gaming, OnLive is remarkably close to the traditional game experience. The problems arise when you play games that require quick reaction times such as racing titles – here, the controls do start to feel a little sluggish as internet speed inconsistencies become more apparent. However, this will only improve as OnLive adds more servers and UK broadband quality improves.

Although the service currently enjoys support from many of the world's biggest publishers such as Ubisoft, THQ and 2K Games, the absence of EA and Activision titles is a significant detraction. This means no *Call Of Duty* or *FIFA*, which have consistently been the two biggest-selling series in the UK over recent years, but as long

as OnLive enjoys continued success, it will inevitably attract more publishers and games.

Right now though, the service's key advantages come down to a wide range of payment options (particularly the great value PlayPack bundle) and the ability to play some of the most graphically demanding games without a high-tech PC or console. If you don't already own a console and your PC is a bit behind the times – or you own a Mac – then OnLive offers the cheapest and most versatile way to enjoy games

Gwynne Dixon is deputy editor of www.totalvideogames.com

Objects of desire



Little big shot

Don't be fooled by its diminutive size, the Nikon 1 J1 isn't an ordinary compact camera. With interchangeable lenses coupled with a large and lightning-fast image sensor, this camera takes pictures that you'd normally need a much larger, professional standard DSLR to capture. It also boasts unique features like the Motion Snapshot mode, which simultaneously records slow-motion HD video and takes a still, so you won't miss any of the action.

Nikon 1 J1 (10-30mm kit)

Price: £549.99

Info: www.europe-nikon.com

Tank commander

This remote-control tank generates its own Wi-Fi signal, which you can wirelessly connect to an iPod, iPhone or iPad. Once linked, video from the tank's camera is beamed to your iDevice, which you can use to 'drive' the vehicle. Spot something interesting and this 30 x 30cm (approx) tank can capture stills and record clips. And if, for some reason, you're doing this in low light, it even has an infrared night-vision setting.

Rover app-controlled spy tank

Price: \$149.99 (£93.64) plus P&P

Info: <http://j.mp/SpyTank>



Let it slide

Make the most of any snowfalls this winter with this high-tech Fantom-X sled. Once you've hauled it uphill (a task made easier thanks to its lightweight alloy frame), you sit on the nylon mesh that's suspended across it to provide the comfort of a hammock before hurtling back down. And to reduce the likelihood of all that hurtling leading to you hurting yourself, you can use the handlebars to steer the skis it runs on.

Snow Boogie Fantom X Sled

Price: £99.99

Info: www.firebox.com

Head case

You might be familiar with Brembo as a manufacturer of high-performance brakes, but now it's taken to redesigning the motorcycle helmet. Brembo's approach offers the rider a larger field of view than most full-face helmets – helping you avoid any nasty accidents in the first place. And its patented continuous chinstrap can be loosened or tightened at the press of a button rather than having to fiddle with buckles.

Brembo B-Tech

Price: €350 (£308.60) plus P&P

Info: brembohelmets.com



All-seeing eye

We've all taken out-of-focus photos before, but what if you didn't have to focus a shot at all? This is exactly what the Lytro allows you to do. It's a new type of camera, available with either 8GB or 16GB of memory, that captures as much information as it can about how the light has entered it. You just take your shot and then, with the help of software bundled with the camera, simply pick the part of the image you want to sharpen.

Lytro

Price: \$399 8GB/\$499 16GB (£253/£316) plus P&P

Info: www.lytro.com

Sweet talker

Samsung's new smartphone was made in collaboration with Google, so it's the first to bear the search engine giant's newest operating system Android 4.0, dubbed Ice Cream Sandwich. Its impressive host of party tricks include voice input for typing and facial-recognition software that uses your visage in place of passwords. It also has near-field communication technology so you can use it to make payments simply by tapping it on an appropriate receiver.

Samsung Galaxy Nexus

Price: TBC

Info: www.google.co.uk/nexus



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FITNESS

James Witts gets physical with 21st-century training tools to keep those New

Best for... swimming

PoolMate Pro

How many times have you completed a swim but been clueless as to how many lengths you managed? The PoolMate Pro solves this problem via a series of accelerometers that capture the motion of your arms for all swim strokes. In turn, you're given lap times, laps completed, average strokes per lap, speed, distance and calories burned. You can then download the data to your computer and relive your dip in graph form. As the year progresses, your swim history will fill up and you can examine your progress and see how far you've swum.

The only downside is that the relatively cheap price is reflected in its looks.



£109.99

www.swimovate.com

Best for... running

Polar RCX5

The sleek RCX5 offers a multitude of training features, including a heart-rate monitor. But its key sell is the GPS facility that, unlike the erratic Nike TomTom, picks up a signal quickly and rarely loses it. Simply strap on the GPS armband and you're confronted with pace per mile, speed, distance run and Race Pace – a neat feature where you train against your intended performance. Once your session's complete, you can download all the data to polarpersonaltrainer.com. There you can map where you ran, how quickly you went and at what level of pain, before sharing it with the world thanks to the social community option. You can cycle with the RCX5 too, and extra sensors are available to monitor your pedalling.



£359.50

www.polaruk.co.uk

GADGETS

Year's resolutions going past January



Best for... cycling

Kurt Kinetic Rock and Roll Turbo Trainer

Icy roads, heavy traffic, dark days – yes, winter cycling in the UK is for the brave or stupid. Turbo trainers leap over this climatic hurdle by letting you ride your bike indoors. You simply clamp your bike into the unit and, as you pedal, your rear wheel spins against a roller that provides resistance. Where the Kurt Kinetic differs from most turbo trainers, however, is that it offers a more realistic ride feel by letting your bike sway from side to side. It's incredibly quiet and offers decent resistance but it's the unique rocking movement that makes you feel as if you're really riding rather than just pedalling an exercise bike. The only causes for concern are its hefty size and price.

£449.99*

www.chocolatedistribution.com

Best for... all-round fitness

Concept2 Rower Model D with PM4

Sir Steve Redgrave's Olympic success saw a surge in sales of rowing machines. Concept2 provided the majority of these and the Model D is its latest. Instead of pulling an oar, you pull a handle. And instead of the resistance of the water, you work against the 10 levels of resistance provided by the fan. The PM4 computer monitors your speed, strokes per minute and pace. However, we recommend linking the rower to a PC and downloading the Row Pro software (www.digitalrowing.com) that includes many features and also lets you race against others online. Overall, it provides a great all-over workout at an acceptable price considering what you get, but its size means those in studio flats should look elsewhere.

£1,127.50

www.concept2shop.co.uk

Best for... fun

ElliptiGO 8C

Ever used a cross-trainer at the gym and harboured a desire to take that training concept onto the street? No, we haven't either but that's the idea behind the ElliptiGO 8C trainer. And, as it turns out, it's rather fun. The drivetrain sits above the back wheel, and you provide the power to propel it by standing on the ski-like pedals and running. You have eight gears, and with the lowest you can negotiate a reasonably-sized hill. While you attract attention – not always desired on the cycle paths of Bristol – it provides the benefits of running but without the risk of injury from sustained impact. At just under £2,000, however, it will wound your wallet. One moot point: handling takes some getting used to.

£1,999

www.elliptigo.com

*Front wheel riser sold separately (£29.99)

What we tested

HTC Titan

running Windows Phone 7.5

Apple iPhone 4S

running iOS 5

Motorola Atrix

running Android 2.2 (Froyo)

BlackBerry Torch 9860

running BlackBerry OS7





Do-it-all Smartphones

Jacks of all trades or masters of none? The versatility of four of the newest smartphones is put to the test by **Daniel Bennett**

Ten years ago, a mobile phone would be judged on its call clarity, whether or not it was WAP-enabled (so it could log on to an early form of the mobile internet) and how good its ringtones were. Thankfully the polyphonic ringtone is dead and now phones boast dedicated mobile operating systems, all manner of applications (apps) and powerful dual-core processors.

More than ever before, the smartphone is vying for total domination of your pocket – ousting the MP3 player, camera and personal organiser in the process. Whether you want to bid on a Brian Cox DVD being auctioned on eBay or tell your friends what constellation

they're looking at, there's very little a smartphone can't do. They're the digital equivalent of a Swiss army knife.

But how good are they at what you'll be using them for most of the time – or rather, what you'll use them for when you're not making calls? Apple's App Store may house everything from cookbooks to cloud-storage apps but how good is the iPhone at finding a route to that new restaurant or at messaging your friends and family? And are any of its rivals any better? To find out, we tested the latest crop of smartphones, sporting four different operating systems, to see which really is the most useful device to have in your pocket. ►



Getting from A to B

The maps function should be fast, simple and packed full of info on local streets and businesses

BlackBerry's first button-free phone has a 3.7in screen, which should make it a lot better for reading maps than its smaller ancestors. But testing this theory was difficult because the maps app doesn't appear on any of the default screens, and locating it required quite a bit of digging through the menus. And it's little surprise it's hidden, because most of the locations we searched for returned a rather unhelpful "Unknown Error" message. We did try some other navigation apps available on BlackBerry world, but they invariably faltered and we couldn't tell if this was down to the phone or the app.

Both the **Atrix** and the **iPhone** rely on Google's own map system, which is

immediately familiar. In our test, the iPhone managed to pinpoint *Focus* towers and the route to the nearest phone shop a little quicker than the Atrix, though it was nothing to text home about.

The real surprise was the **Titan**. Its 4.7in screen squeezes far more info into view, and its Bing-powered search seems to load your location and the map almost instantly. Its turn-by-turn navigation splits the screen in two, with the map shown in the top half and directions in a large font at the bottom. This makes it far easier to use as a guide than its competitors, although we're not sure this would be as easy to use on a smaller Windows phone.



Multimedia

Videos should play without fuss, while each phone's media player should support a variety of formats and offer extra features

Of the four, the **iPhone** plays the fewest video and music formats. Plus everything has to go via iTunes – you can't simply drag and drop files from your computer on to your phone. While this is annoying, iTunes's well-stocked library makes it easy enough. The iPhone's super-sharp display will highlight bad video quality but provides the best detail with decent-quality clips. Also, if you own an Apple TV (£99) you'll be able to stream video wirelessly to your TV; the same goes for music with an Airplay-enabled dock.

Video and music playback on the **Atrix** is solid and it's the only other phone that makes sending its media to a bigger screen easy (with an additional HD TV dock costing £50). But the Atrix's real party trick comes when you plug it into

the laptop dock (£250). The dock is little more than a screen and keyboard but the phone provides the processing power to make it work as a netbook.

In the past, media would have been a **BlackBerry**'s weakness but the Torch's screen is great for watching video and does a good job of upscaling poor-quality footage. But it lacks the sheer versatility of the other phones on test.

The **Titan**'s huge screen is a big boon again, making it the most enjoyable to watch video on, and while Microsoft's Zune makes synching files a pain, the design of the media player is the best here.

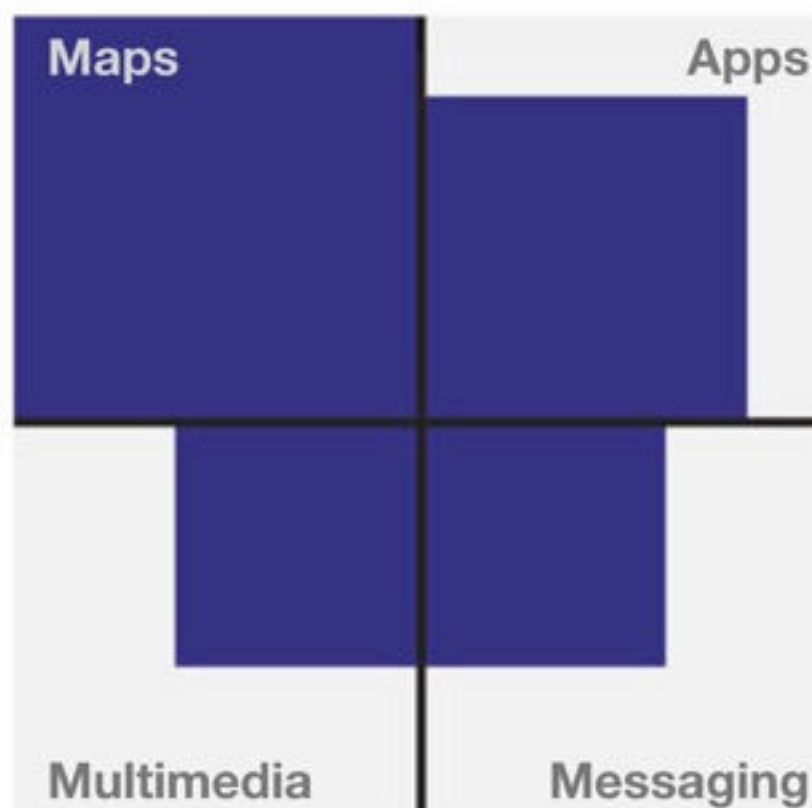


HTC Titan

£459.99

www.htc.com

Processor: 1.5GHz chip; OS: Windows Phone 7.5; Memory: 512GB RAM; Storage: 16GB expandable up to 32GB; Display: 4.7in, 800 x 480; Camera: 8MP, 720p HD video; Battery life: 6.8 hours talk time



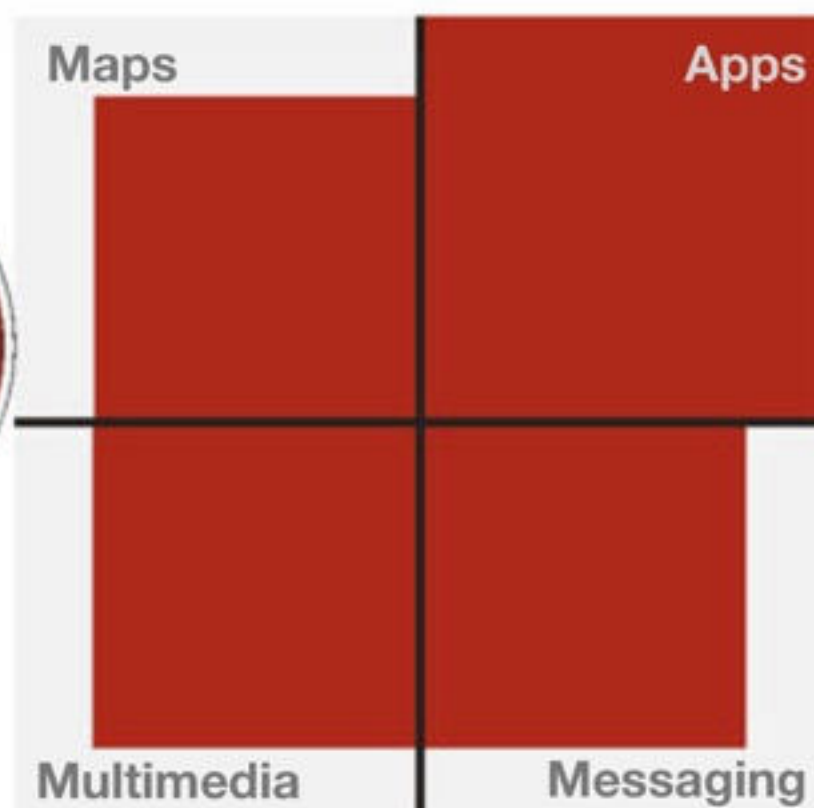
The Titan is well built and the screen is great for watching movies on but Windows Phone 7.5 has a few early teething problems that hold it back.

iPhone 4S

From £499.99

www.apple.com

Processor: Dual-core 1Ghz A5 chip; OS: iOS 5; Memory: 512MB RAM; Storage: 16GB; Display: 3.5in, 900 x 640; Camera: 8MP, 1080p HD video; Battery life: 8 hours talk time



While the iPhone isn't perfect, there's very little it doesn't do well. It's a well-rounded device that's hard to fault.



Apps

A smartphone is nothing without apps. They should be plentiful and make the most of the handset's abilities

Apple's App store will furnish your **iPhone** with the best apps money can buy. It also tends to be the place where new apps land first, before developers jump over to its rivals.

While the Android Marketplace and the **Atrix** can't match iTunes for its sheer wealth of apps, it's not far off. There's usually an equivalent app to something iOS specific, if you're willing to look hard enough. It also offers something slightly different: the apps are cheaper (more often free) and tend to be more specialised as the Android community responds to user requests for apps.

Compared to these two app stores, Windows Phone 7.5 on the **Titan** is a

newcomer. Since its launch a year ago it's done a great job of stocking its app shelves, though they're still a little bare. The presentation and organisation of all the apps is as good as Apple's and it feels slicker than Android. Windows's killer feature, though, is its live tiles. Instead of static icons, the apps display information as buttons. For example, the weather app will let you know the forecast at a glance, and the photo gallery icon will display a slideshow of your pictures.

Despite a reasonable effort, **BlackBerry's** App World pales in comparison to the others. You'll find great apps inside – though mostly for business use – just not enough of them to keep you coming back for more.



Messaging

Keeping in touch with people via text, email and social networks should be just as easy, if not easier, than doing it from a computer

The **iPhone's** messaging and networking apps are simple to use, and will automatically send a free message if your contact has an iPhone. What's more, its search function is the best here, dredging up ancient emails in no time.

The Windows phone search on the **Titan** is not as strong, making it a pain if you need to find anything quickly. It also lacks built-in free messaging, which is slowly becoming an expected standard on smartphones. That said, the Titan's screen size and Windows Phone 7.5's clear design means emails are clear and easy to read and write – you'll never have to squint.

The **Atrix** and the **Blackberry** can put all your messages into one feed, whether they're via Facebook, email, text or anything else – a handy trick that's absent on the other phones. On the Atrix each of these feeds can be turned into a widget that displays your latest message on the home screen.

The BlackBerry does messaging best of all though, as emails and Facebook messages seem to arrive on this handset quicker than on any of the other phones. Add in the free BlackBerry-to-BlackBerry messaging and it really starts to look like a social networking addict's dream. That said, it might take you a bit longer to reply to messages as the touchscreen keyboard can be frustratingly fiddly at times.

Motorola Atrix

£324.99

www.motorola.com

Processor: 1GHz dual-core NVIDIA Tegra chip; OS: Android 2.2 (Froyo); Memory: 1GB RAM; Storage: 16GB expandable up to 32GB; Display: 4in, 960 x 540; Camera: 5MP, 720p HD video; Battery life: 9 hours talk time



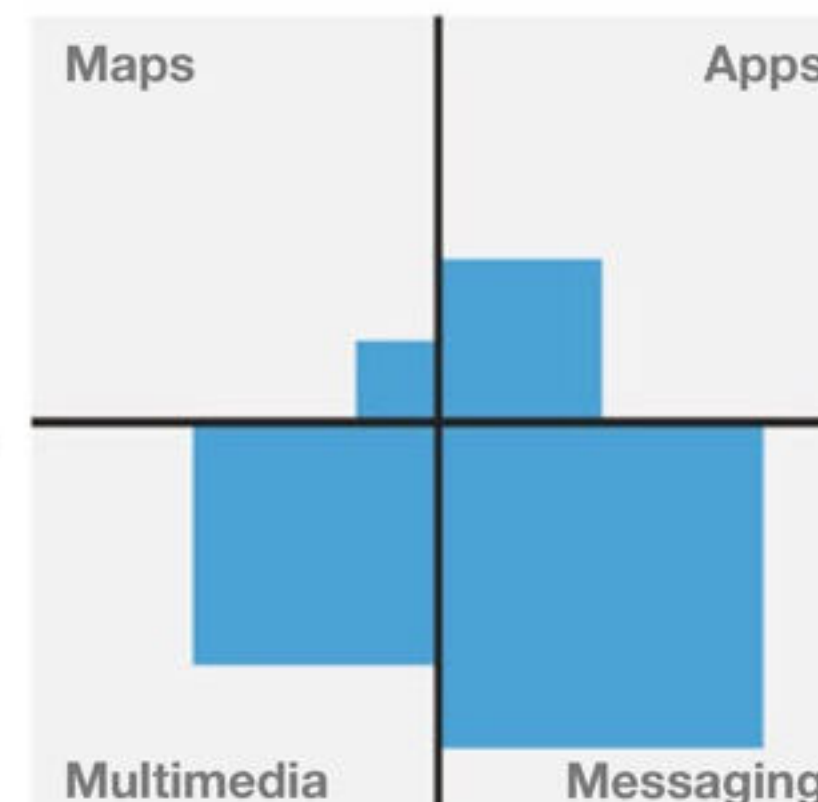
This is the cheapest smartphone here, though it doesn't show in the quality of its features. It only just falls short of the iPhone's high standards.

BlackBerry Torch 9860

£379.99

uk.blackberry.com

Processor: 1.2GHz; OS: BlackBerry 7; Memory: 768MB RAM; Storage: 4GB internal with up to 32GB expandable; Display: 3.7in, 800 x 400 TFT LCD; Camera: 5MP, 720p HD video; Battery life: 6.2 hours talk time



The BlackBerry is a messaging specialist and not much else. It's a nicely made phone but doesn't do much to earn the 'smartphone' moniker.

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How to... RECYCLE OLD GADGETS

If you're lucky, this Christmas might herald the arrival of some new gadgets. But what will you do about the cast-offs?



Recycle

Why chuck your old phone or computer if it still works and could be used by someone else? Organisations like Computer Aid International and Mazuma Mobile will refurbish old devices and send them to the developing world. Some PC and TV makers offer 'take-back' schemes for their products, and many will give you cash in return for a device. Recycleyourgadget.co.uk will help you shop for the best deal.

Wipe

It's worth wiping devices before you donate them so you don't pass on any sensitive info. Either remove the SD card or format it from the phone's menus. The SIM card also needs to come out. Then do a factory reset for good measure. To wipe a Mac, look for the Erase tab under Disk Utility (in the Utilities folder, in Applications). Wiping a PC is trickier but Darik's Boot & Nuke freeware does a good job (www.dban.org).

Reuse

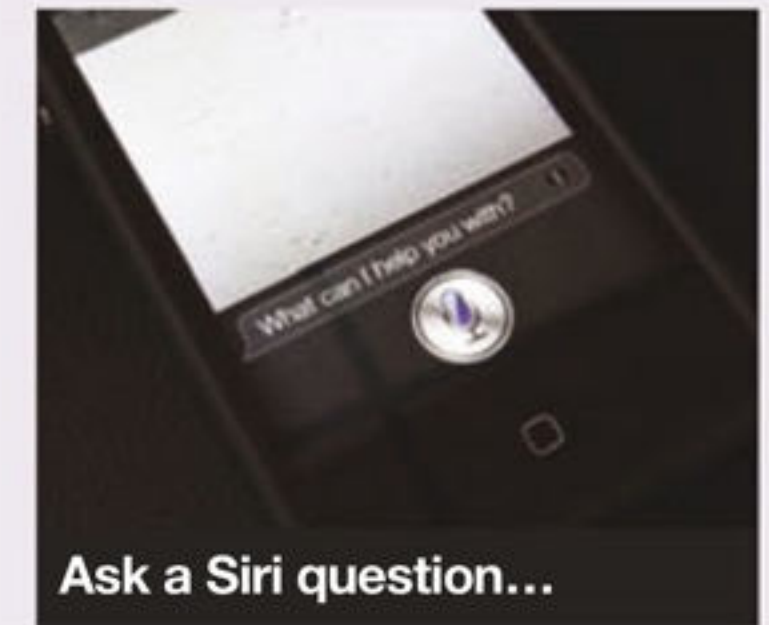
Alternatively, why not reuse bits of your old machine yourself? You could repurpose your entire laptop or PC, by turning it into a media centre or DVR. Free media centre software from XBMC, or free DVR software from MythTV, will transform your old computer into a slick set-top box. The addition of a HDMI cable – the type will depend on your computer – will let it run your entire home entertainment system.



It was while I was sitting in traffic that made me miss my train, that I came up with my dream smartphone

app. A personal assistant that was smart enough to understand the journey I'd take the next morning, monitor the road and rail situations, and, if necessary, wake me up earlier so I still get in on time.

It's a big ask. A program that understands your request, goes looking for the relevant information online, interprets it, performs whatever calculation it deems necessary and then acts accordingly. Mind you, it's encouraging to see that the technologists are working on it. Siri, the voice-activated personal assistant in the



Ask a Siri question...

iPhone 4S, has received praise for its ability to act on simple instructions and requests.

But if you've used it, I'm sure by now you'll have already hit the upper limits of its capabilities. Yes, it can recognise your spoken words – sometimes – and search for them within apps, contacts and a list of other pre-programmed answers that give Siri its 'personality'. But ask it to do something outside its remit, or using anything other than the words it knows, and it's a lot like talking to a deaf, elderly, foreign aunt. There's lots of shouting and repetition before you give up and do it yourself.

Understanding everything we say, and what we actually mean, needs supercomputer power. Fortunately, we have access to this already – in the cloud. Once we all have universal, super-fast mobile internet, everything can be uploaded. Huge machines in the cloud will take up the strain, and send us more satisfactory results. And, more importantly, I will always get to work on time.

Spencer Kelly is the presenter of the BBC's technology show *Click*

Tech Doc's app prescription



LHSee
Android

One for hardened physics fans – an app that puts you inside the Large Hadron Collider at CERN. After watching the tutorial on how the enormous machine works, you can take a 3D tour of the various parts of the LHC, and get inside the collisions happening right now. Just mind your bosons.



GOODPLAYER
iOS

Apple's native media player can only play a limited number of video file types, so if you want to watch something you didn't get through iTunes, Goodplayer is for you. It can handle a huge variety of video formats and allows you to load files onto your device without using iTunes at all.

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andy pad



andy pad pro



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Jane Douglas

Being difficult

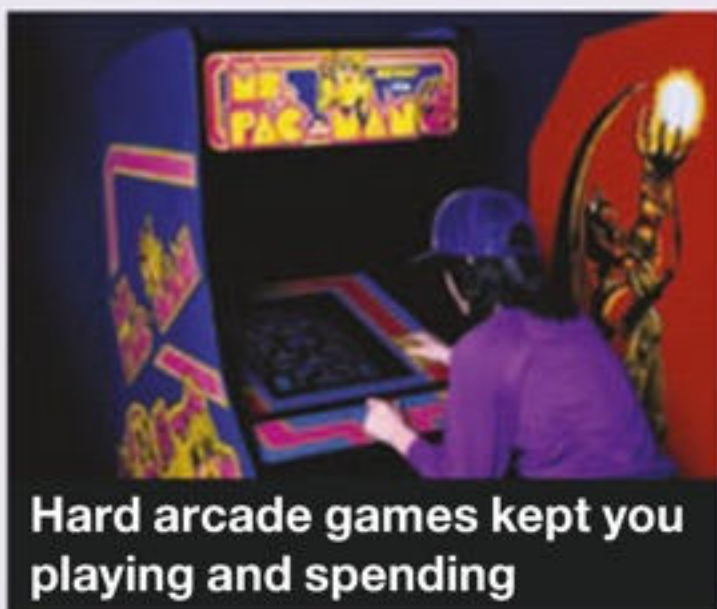


When medieval fantasy title *Dark Souls* launched in October, glowing reviews praised its fiendish difficulty.

'Prepare to Die' went its tagline, clearly stating the expectation that you'd die repeatedly and punishing less skillful players in a way that's rare in mainstream games.

But we aren't all masochists desperate for games to tell us we're a bit rubbish. *Dark Souls* earned its praise by matching difficulty with the gratification of hard-won progress. There's also the prestige that comes with beating a notoriously tough game in an era when games, maybe, aren't as hard as they used to be.

Old-school gamers will tell you we've collectively gotten soft. In the golden age of the arcade, lives cost coins so difficulty was profitable. At



their peak in 1982, US arcade machines took \$8 billion in quarters. But profits dropped to \$2.3 billion by 1994, and by 2004 it was just \$866 million.

Today, arcades are niche, whereas casual gaming on mobile devices and home consoles is riding high. When *Gears Of War*, by no means a 'casual' game series, makes its lowest difficulty "even easier" and adds a multiplayer area especially for terrified beginners, you know inclusion and accessibility are king.

That also comes with a corresponding re-labelling of difficulty settings. *Gears Of War 3* describes its 'hardcore' mode as 'Gears at its finest', while *Halo* labels its 'heroic' mode as 'the way Halo is meant to be played'. Neither is the hardest setting – they're simply designed for those who've played previous games. So we can die just as many times as we used to, but we'll feel better about it when we do.

Jane Douglas is section editor of GameSpot UK

The only thing Batman hates more than a psychopathic villain in fancy dress is a malfunctioning neon sign



BATMAN: ARKHAM CITY

X360, PS3, PC
Rocksteady, from £34.99

Superhero simulators don't come better than this bold, beautiful open-world adventure. It's set in the gothic prison ghetto of Arkham City – several blocks of Gotham sealed-up to incarcerate the murderous thugs and criminally insane of Batman's home town. Inside, the Dark Knight's numerous nemeses are vying for control. While gang warfare rages on the ground, you soar above, utility belt loaded with bat-gadgets, pursuing mission objectives or detouring for side quests.

Batman's strength and vulnerability are perfectly balanced, making him both elite street brawler and invisible stalker, striking from the shadows to pick off armed goons. The hand-to-

hand combat is also an achievement: an elegant, empowering system built on timing your blows and countering those of the enemy.

Swooping around using the hang glider-like cape and grappling hook is endless fun, and made sublime by the city's decaying beauty. The night sky is busy with neon lights and patrolling helicopters, while the familiar villains, including the Joker, Two-Face and Penguin, have each converted grand old buildings into fortresses and hideouts themed on their particular madness. In any other game, a setting like Arkham City might steal the show, but it's no less than the Caped Crusader deserves. ●●●●●



ALSO OUT

UNCHARTED 3: DRAKE'S DECEPTION



PS3
Naughty Dog
£49.99

Treasure hunter Nathan Drake returns and this time the bond with his disreputable mentor Victor Sullivan is at the heart of the story. The brawling has been beefed up but acrobatic clambering and cover-based shooting is still the name of the game, and still excellent fun. For spectacular action, luscious environments and breezy storytelling, *Uncharted* is the gold standard. ●●●●●

SQUIDS



iPhone, Android
Game Bakers
69p, TBA

A pleasing mix of turn-based strategy and touchscreen play, *Squids* has you ping-pong the tentacled sea creatures around underwater vistas as though they were rubber bands. You control a small squad of the critters, using them as projectiles to attack your enemies and bump them over edges. Then you watch as your foes take a turn at doing the same to your crew. Very pretty and smarter than it looks. ●●●●●

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0115 945 5522

Bill Thompson

Coding for kids



I grew up in a world without visible computers. They existed, of course (I'm not quite that old) but they were locked away in businesses or universities, tended to by expert systems administrators. And if they were accessible at all, it was through teletype terminals that used typewriter keys and printed output on long rolls of paper. As I left school, the first personal computers were being released: systems like the Commodore PET and, later, the BBC Micro. Many people had games machines such as the Sinclair Spectrum, with programs loaded from cassette tape or painstakingly typed in from printed listings in magazines.

Today, computers are everywhere. Few of us know how many microprocessors are in a car or microwave, and many of us carry around powerful smartphones, ultra-light laptops and even the odd iPad or Android tablet. We rely on these systems to run our lives but fewer and fewer of us have any idea how they work.

While there are many reasons for this, not least the complexity of modern computing environments, part of the blame for our lack of understanding is that schools have turned away from teaching computing. In schools, Information and Communications Technology (ICT) means learning how to use a word processor, spreadsheet or database and knowing how to search the web.

This may not seem to matter much. After all, how many of us can repair a car engine or service a central heating system? But there's an important difference, as connected computers are fundamental to so many aspects of our lives, and not knowing how they work makes it less likely that we'll be able to assert adequate control over them.

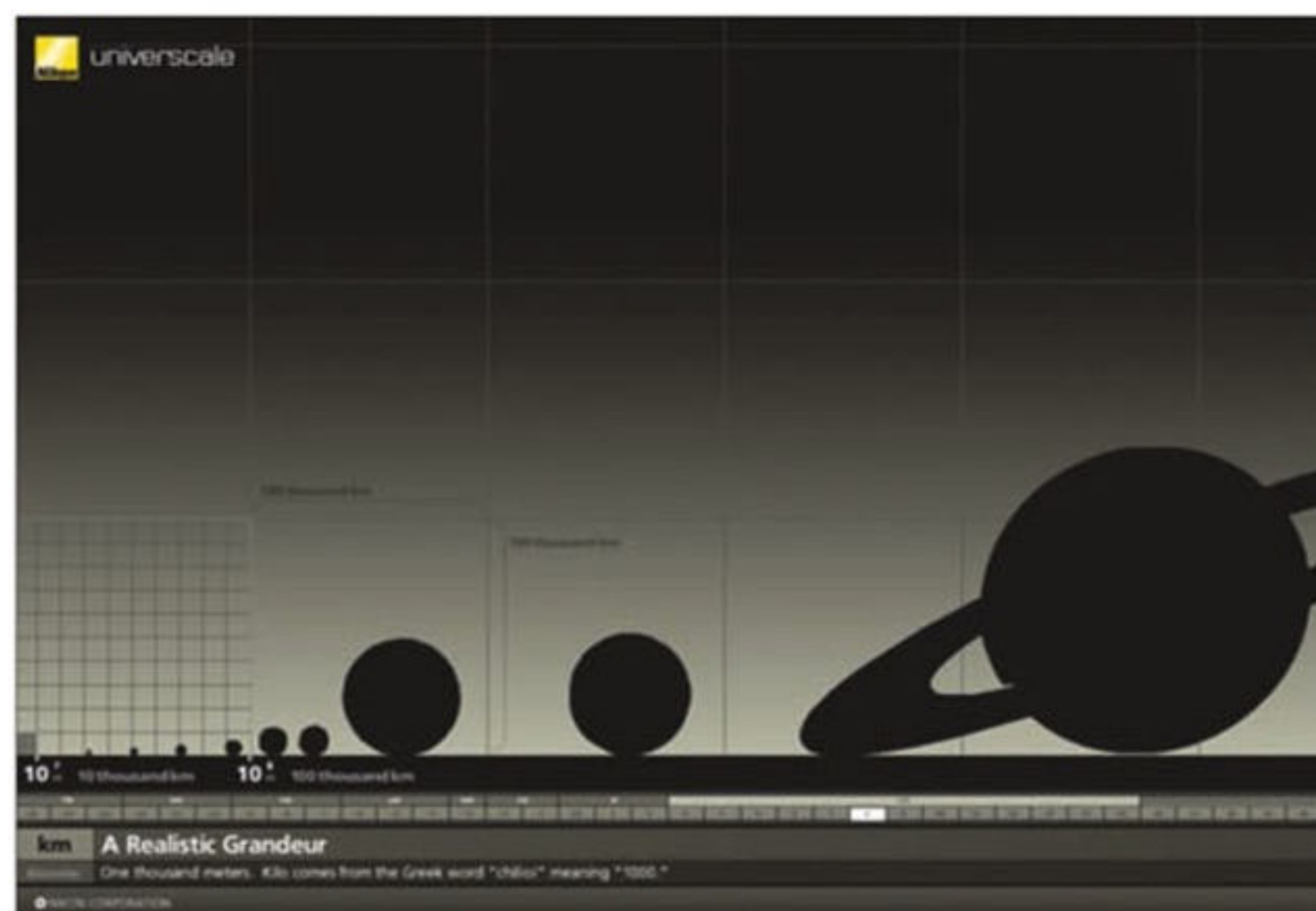
The poor quality of UK computer education was highlighted in a speech given last autumn by Google's former CEO, Eric Schmidt. In it he admitted that he was "flabbergasted to learn that, today, computer science isn't even taught as standard in UK schools," and said this meant "throwing away your great computer heritage." In response, Education Secretary Michael Gove announced plans to strengthen the computing components of the ICT curriculum, and the 'Coding For Kids' movement was established.

We've yet to see what impact these initiatives will have, but I'm grateful that the question is at least on the agenda. As a programmer myself, I know just how important it is to understand the machines that increasingly shape our daily lives.

Bill Thompson contributes to news.bbc.co.uk and the BBC World Service

Nikon Universcale

<http://j.mp/universcale>



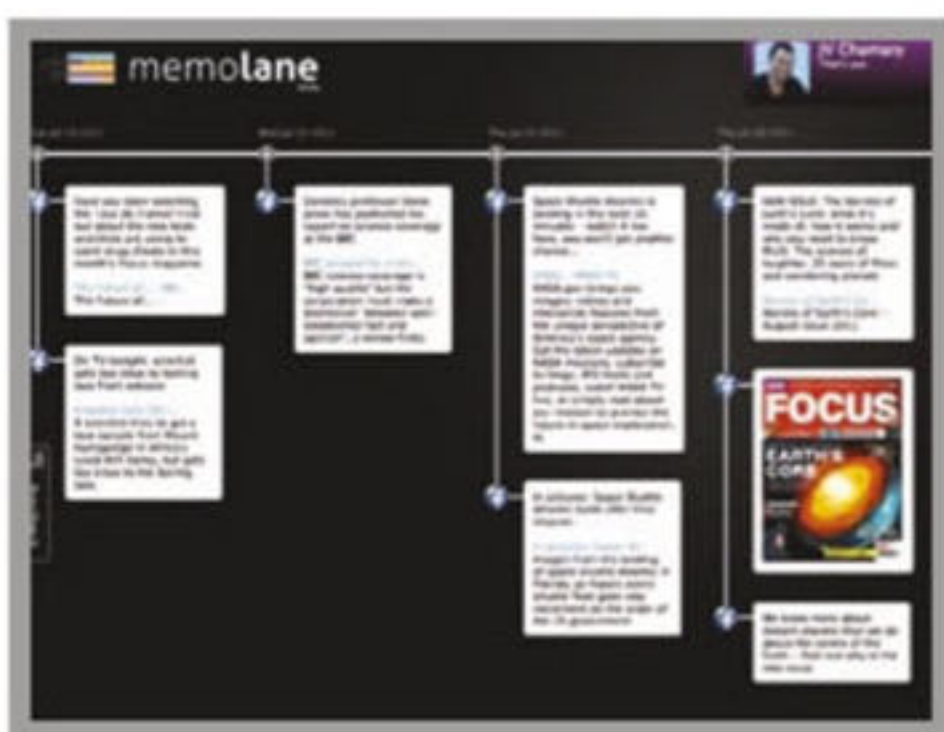
This site from Nikon does a good job of representing the sheer scale of things from sub-atomic particles through to the limits of the observable Universe. Clearly inspired by *Powers Of Ten*, the enormously influential 1968 film by Ray and Charles Eames, Universcale is a Flash-driven site that lets you scroll through the silhouettes of various objects to give you a sense of how a human compares to a flea, or a star to a galaxy.

There's something lovely buried in this site but you have to wade through a lot of pretentious writing of dubious scientific validity to get to it. And that's a real shame because the idea is an attractive one. Lines like "Unfortunately the size (weight) of the quark is too small to be measured" should never have got through the editing process. If Nikon had used a proper science writer then this would have been a useful site to encourage us all to think about scale and our place in the Universe.

WEB HACKS

Curate your online life with Memolane

Why? If, like me, you're on Twitter, Flickr, Facebook, Google+, Spotify and many other services, then keeping track of what you've posted or said is an impossible task. And while Facebook now offers users a 'timeline' that captures all your activity on the site and presents it as an easy-to-navigate chronology, it will only show you the stuff you chose to share on Facebook.



What? Memolane takes this a step further, pulling posts from a growing range of online services and using them to create a scrollable timeline that you can search and share. You can share your personal timeline via the Memolane site or embed it in your own blog or website following the instructions on the site.

How? Create a (free) account at memolane.com and register your various accounts with it. Then give it access to your various social media accounts, and see what it generates. You can keep individual accounts or your whole timeline private. As ever you should be careful what you share, though Memolane asks for read-only access to your account, so it won't be posting in your name.

Boing Boing Science

<http://j.mp/boingsci>



Boing Boing is one of the most popular blogs on the web, possibly because its editors collect and post a fascinating range of material on every subject, and don't take themselves too seriously. Its eclectic curation policy is too much for some but, fortunately, you can just look at its high-quality science coverage through the 'science' tag. It's well-written, only a little bit obsessed with squid and often features great photos and videos.

NASA Be A Martian

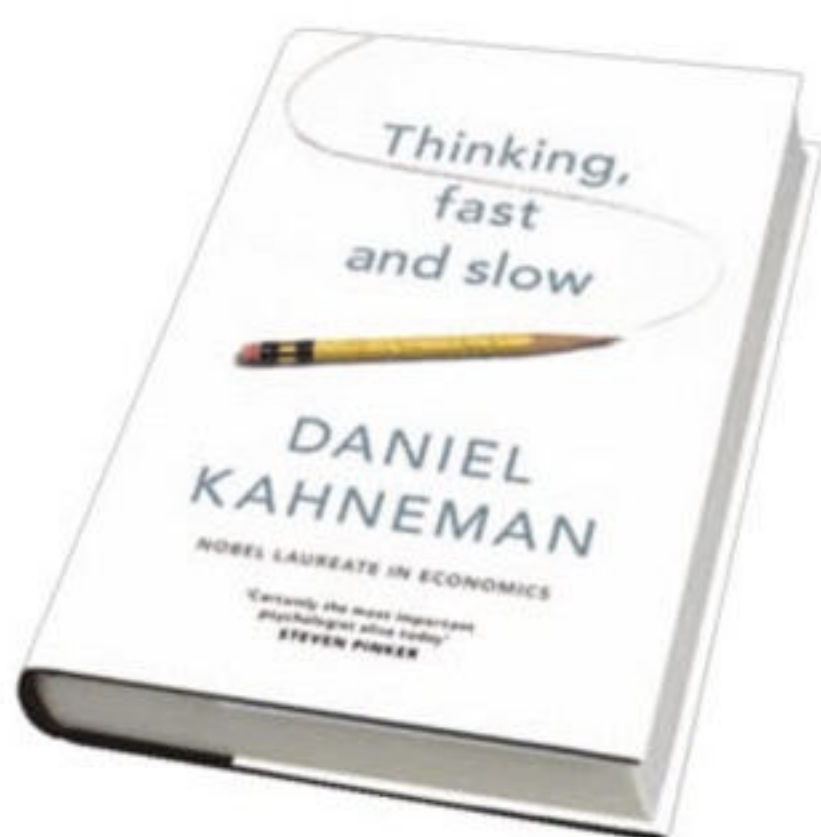
<http://j.mp/nasamartian>



This site from NASA and Microsoft offers visitors a chance to contribute to the ongoing Mars research programme while finding out more about the planet. You can send virtual postcards, ask questions about Mars or do some citizen science by counting craters. Requiring Microsoft's Silverlight plug-in for your browser in order to use the interactive features may put some people off but this is a delightful site.

Thinking, Fast And Slow

An enlightening exploration of the magic that makes our minds work, says **Pete Lunn**



Daniel Kahneman
Allen Lane, £25
(512pp, hbk)

Top experimental psychologists come across as part scientists, part conjurers. In *Thinking, Fast And Slow*, Kahneman, Nobel prize winner in economics and an exceptional psychologist, treats readers to some of his best tricks.

Kahneman calls the phenomena he studies 'cognitive illusions', and the aim of the book is to give away how it's all done. We're invited to perform simple experiments on our own minds, then offered unnerving explanations for the frailties that these demonstrations expose.

For Kahneman, the experiments show how the mind is best thought of as two systems with distinct personalities. 'System 1' is like a computer – an automatic, subconscious, parallel processor of unimaginable breadth and speed, honed by thousands of adaptations to

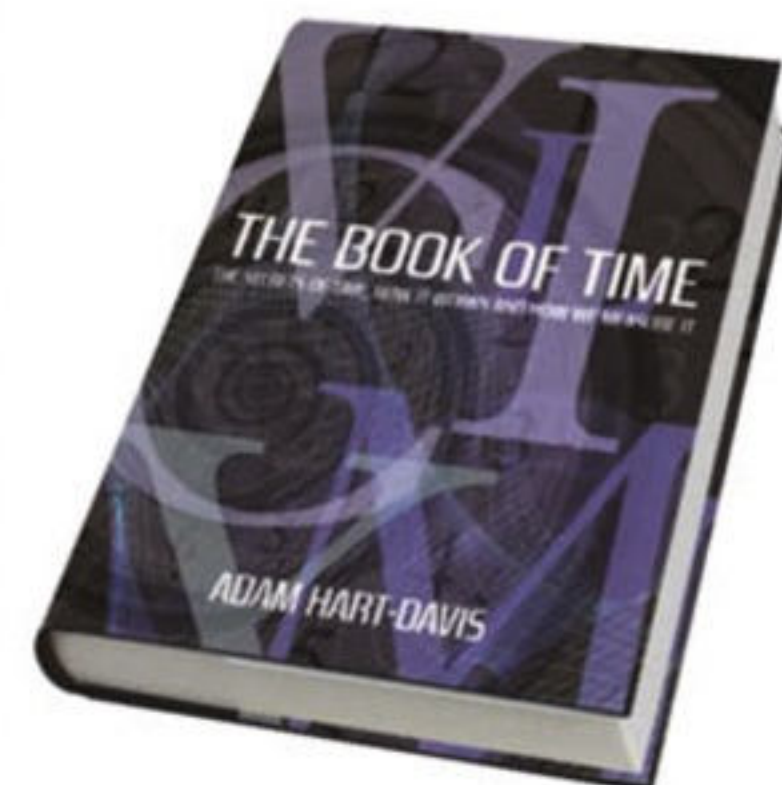
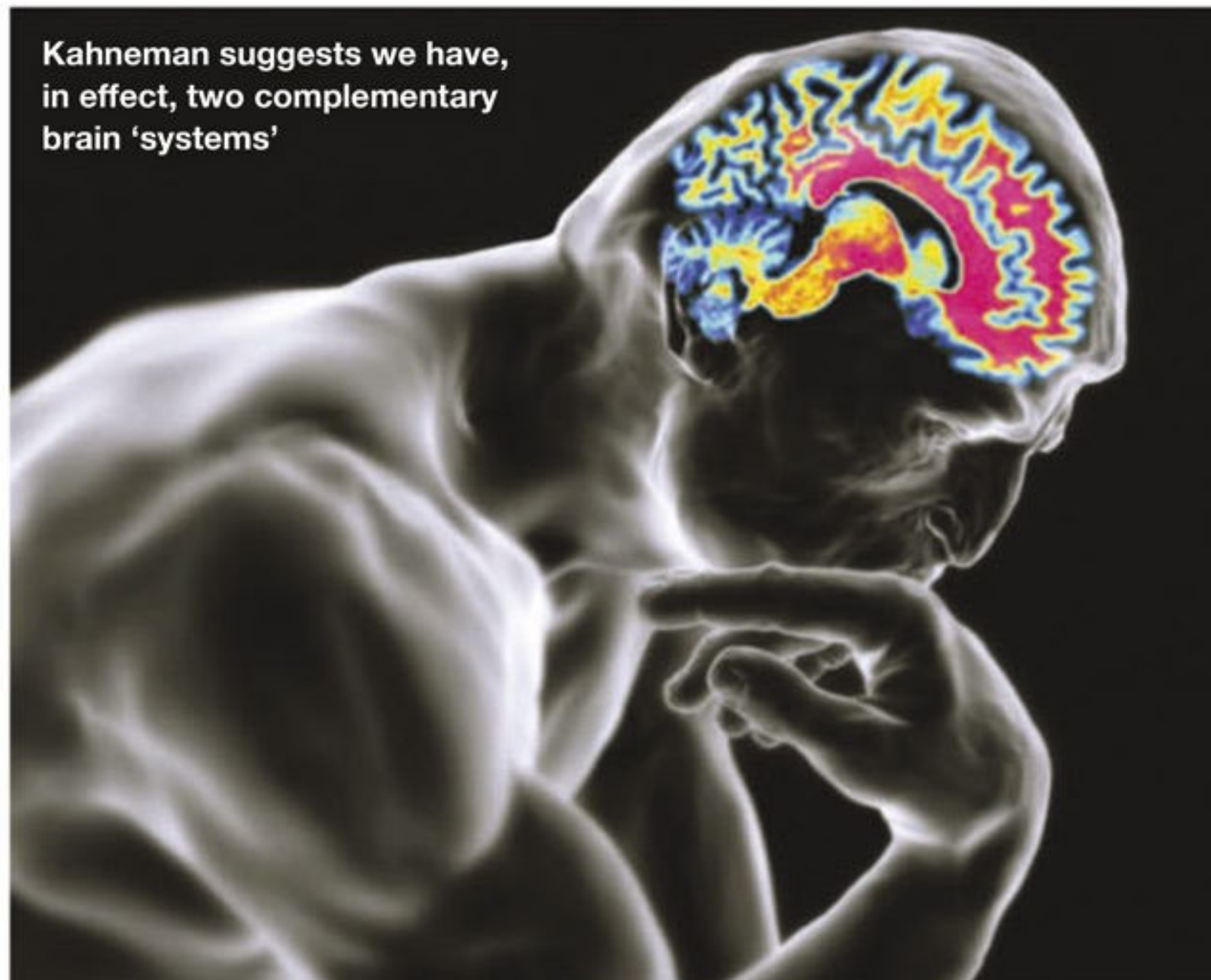
historic environments it mastered better than rival models. Yet this remarkable machine is ill suited to modern living: System 1 is prone to biased statistical intuitions and misleading associations, making us prey to illusions.

Enter System 2, the laborious, serial, conscious mind that you and I feel we occupy. With limited time and energy, it relies on our own education and experience. It works things out ploddingly, with effort, attention and concentration, often requiring the help of memory aids and other tools. Kahneman mobilises experimental science to help our System 2 to understand and learn to live with our primitive yet essential System 1.

While it's enlightening and in places brilliant stuff, Kahneman is old-school. His language is testimony to trained precision and an appreciation of fine distinctions. Criticisms of his view of an error-strewn, dual-system mind (and there are good ones) are mostly relegated to dismissive footnotes, of which there are 30 pages. This is not condensed popular science – it's the career thoughts of a top-class researcher, whose subject is fun but whose intent is serious. Time to engage System 2. ●●●●●

Dr Pete Lunn is a behavioural economist and author of *Basic Instincts: Human Nature And The New Economics*

Kahneman suggests we have, in effect, two complementary brain 'systems'



The Book Of Time
Everything You Need To Know About The Biggest Idea In The Universe
Adam Hart-Davis
Mitchell Beazley, £20
(256pp, hbk)

The Book Of Time is a bit disappointing: it's good looking, but also very traditional (a polite term for old-fashioned). Adam Hart-Davis does a good job of telling the old stories, such as those about the ancient Greek philosophers' view of time, biological rhythms, and why we have leap years. But other books do this just as well. There's little in the way of modern science here, which is a pity because there have been recent developments in our understanding of time at both the quantum and the cosmological level.

Worse, there are some serious scientific howlers. Among others, a headline on p87 boldly (and falsely) tells us that "the first oceans appeared 150 million years ago", while on p76 there's an incomprehensible diagram which is captioned as representing nuclear fission but which, if it makes any sense at all, actually seems to represent nuclear fusion.

A young reader with no previous knowledge of our understanding of time would glean a lot from this book, but he or she would need an older, wiser person to highlight the misconceptions. A possible present, then, for a younger relative to whom you can show off how much you know that Adam Hart-Davis doesn't! ●●

Dr John Gribbin is visiting fellow in astronomy at the University of Sussex

Expert Bookshelf

Genomics

The Missing Link

In Search Of Human Origins

John Reader

Oxford University Press, £25
(350pp, hbk)

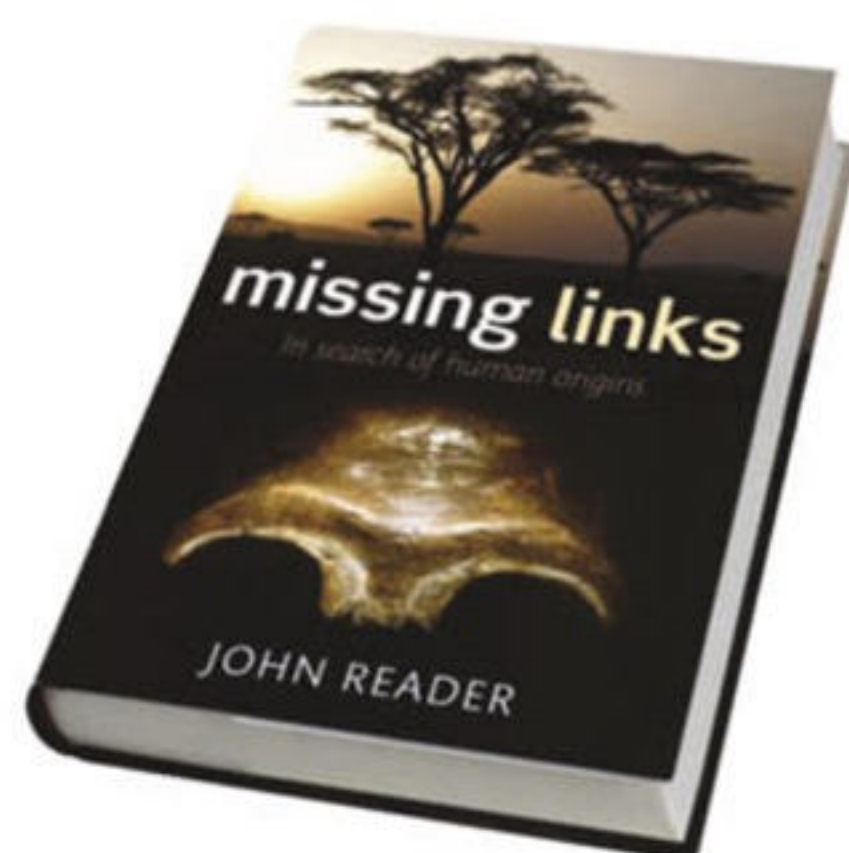
There have probably been more discoveries of fossil humans in the past 30 years than in the previous 300. The past 10 years have been frenetic enough, with the discovery of the 'Hobbits' of Indonesia and the skeletons of *Ardipithecus* and *Australopithecus sediba*, plus the sequencing of the genomes of Neanderthals.

A haul of books has followed these finds. In recent months we've seen Chris Stringer's *The Origin Of Our Species*, Dean Falk's *The Fossil Chronicles*, Pat Shipman's *The Animal Connection* and Alice Roberts's *Evolution: The Human Story*. Publishers have also unearthed Reader's *Missing Links: In Search Of Human Origins*, which first appeared in 1981 and which is seen here in a new edition revised for a new century.

The photography is gorgeous and so is the text. The older sections are rich with detail, some of which I've read nowhere else. For example, I never knew that the Neander Valley, where Neanderthal bones were first discovered, was named after a poet called Neumann, who Latinised his name to Neander ('new man').

The new parts seem a little rushed by comparison, but no matter. You don't really read this book, so much as bathe in it. Which is just as well, as it weighs nearly 1.6kg. ●●●●

Dr Henry Gee is an editor at Nature and is currently writing a book about early man



Chosen by
Lone Frank



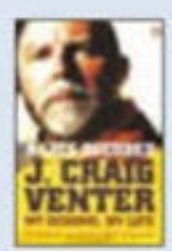
The Selfish Gene
Richard Dawkins (1976)
OUP, £8.99

Dawkins's grand idea opened up a whole world of understanding of what genetics and genomics is all about. It looks at evolution with a gene's eye view, shifting the whole perspective of evolution from groups or individuals to tiny pieces of DNA. This was the book I read in high school that made me want to be a biologist – it opened up my mind.



Rosalind Franklin: The Dark Lady Of DNA
Brenda Maddox (2003)
HarperCollins, £9.99

It's always great to bring historical perspective to a development that's happening today that, for many people, seems to have come out of nowhere. Maddox gives you a glimpse into the workings of science, showing the personalities and egos involved and just how much competition there is. It's also important to realise that all of this only started in the 1950s. Today you can get your whole genome mapped for a few hundred pounds. That's an amazing advance over a short period.



A Life Decoded: My Genome, My Life
J Craig Venter (2008)
Penguin, £9.99

Another historical perspective on how we went from tiny pieces of DNA and hugely expensive procedures to, wow, we can decode the entire genome! Venter's life is in itself such a strange and exciting story. I chose this above, say, a science journalist's account of genomics as Venter writes incredibly well and gives great personal insight. That's necessary for getting into the heads of the people who drive these developments.

Dr Lone Frank is the author of My Beautiful Genome (Oneworld, £10.99)

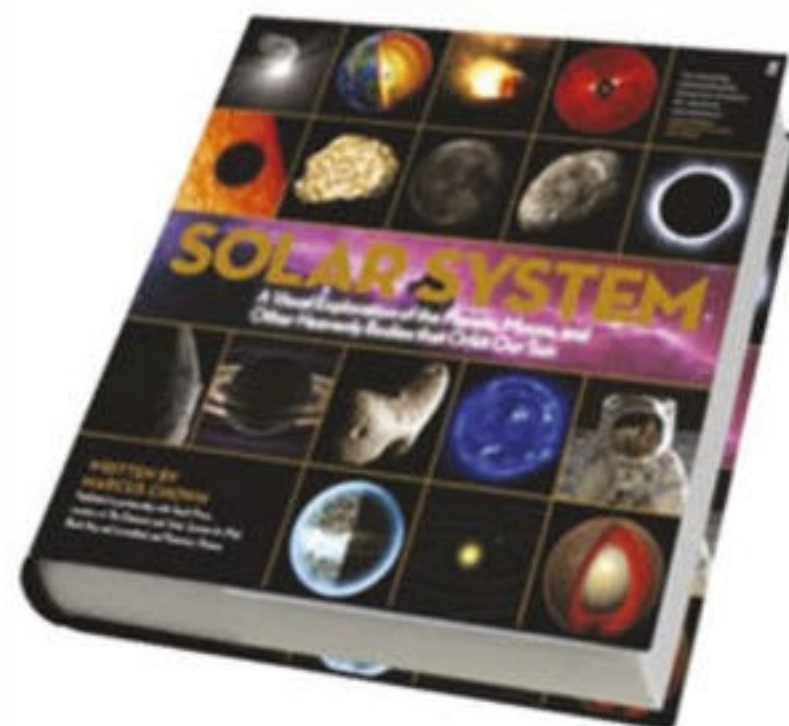
Solar System

A Visual Exploration Of All The Planets, Moons And Other Heavenly Bodies That Orbit Our Sun

Marcus Chown

Faber, £25

(224pp, hbk)



This latest book from science writer Chown began life as an all-singing, all-dancing iPad app. The book's digital genesis is clear to see from its lavish pictures, cutaways and attractive data boxes. The pages are illustrated with large, sharp images, but it's Chown's engaging writing style that really makes this book. Whether it's a discussion of the windsurfing conditions on Saturn's moon Titan or the story of how Pluto's moon Charon got its name, there's plenty of meaty text to inform and entertain you. ●●●●

Will Gater is features editor of Sky At Night Magazine

Science On Ice

Four Polar Expeditions

Chris Linder

Chicago, £26

(288pp, hbk)



Polar bears and penguins steal the show in most photo essays on the Arctic and Antarctica, respectively. This one is different. Here it's the polar scientists and their work who are the stars (or at least objects of curiosity) for Linder. What do scientists actually do on the frozen oceans, in bleak penguin colonies or the slushy Greenland Ice Sheet? And intriguingly, why? Refreshingly, it's not the views, the gadgets or the creatures that jump out from these engaging stories, but the scientists' excitement at chasing their ideas. ●●●

Dr Hamish Pritchard is a British Antarctic Survey glaciologist

Future Science

Essays From The Cutting Edge

Max Brockman (editor)

OUP, £9.99

(272pp, pbk)



If this book is any guide, it won't be long before scientists can no longer win Nobel Prizes. Not because they're not up to it, but because the most important advances will transcend the prize's clapped-out categories of physics, chemistry and medicine. This collection of short essays by up-and-coming scientists shows that the most interesting questions are now coming from multi-disciplinary research into everything from the search for life on other worlds to the limits of human shame. Punchy, provocative and packed with fascinating insights. ●●●●●

Robert Matthews is visiting reader in science at Aston University

THE TO-DO LIST

The essential guide to the month ahead

15^{DEC}



Frozen Planet

David Attenborough takes you on the ultimate polar expedition, from killer whale encounters to erupting polar volcanoes. Plus, on the DVD and Blu-ray there's footage that wasn't shown on TV of the team's unprecedented access to the South Pole Station – the most remote research base on Earth. DVD: £22.49 Blu-ray: £25.99

16^{DEC}

Republic Of The Moon

Long ago, writers and artists like Jules Verne and Lucien Rudaux created visions of what trips into space would be like. Now, as a new, private space race begins, a new group of artists give us their visions of a future lunar 'nation'.

FACT, Liverpool
16 December-26 February, free, j.mp/MoonRepublic

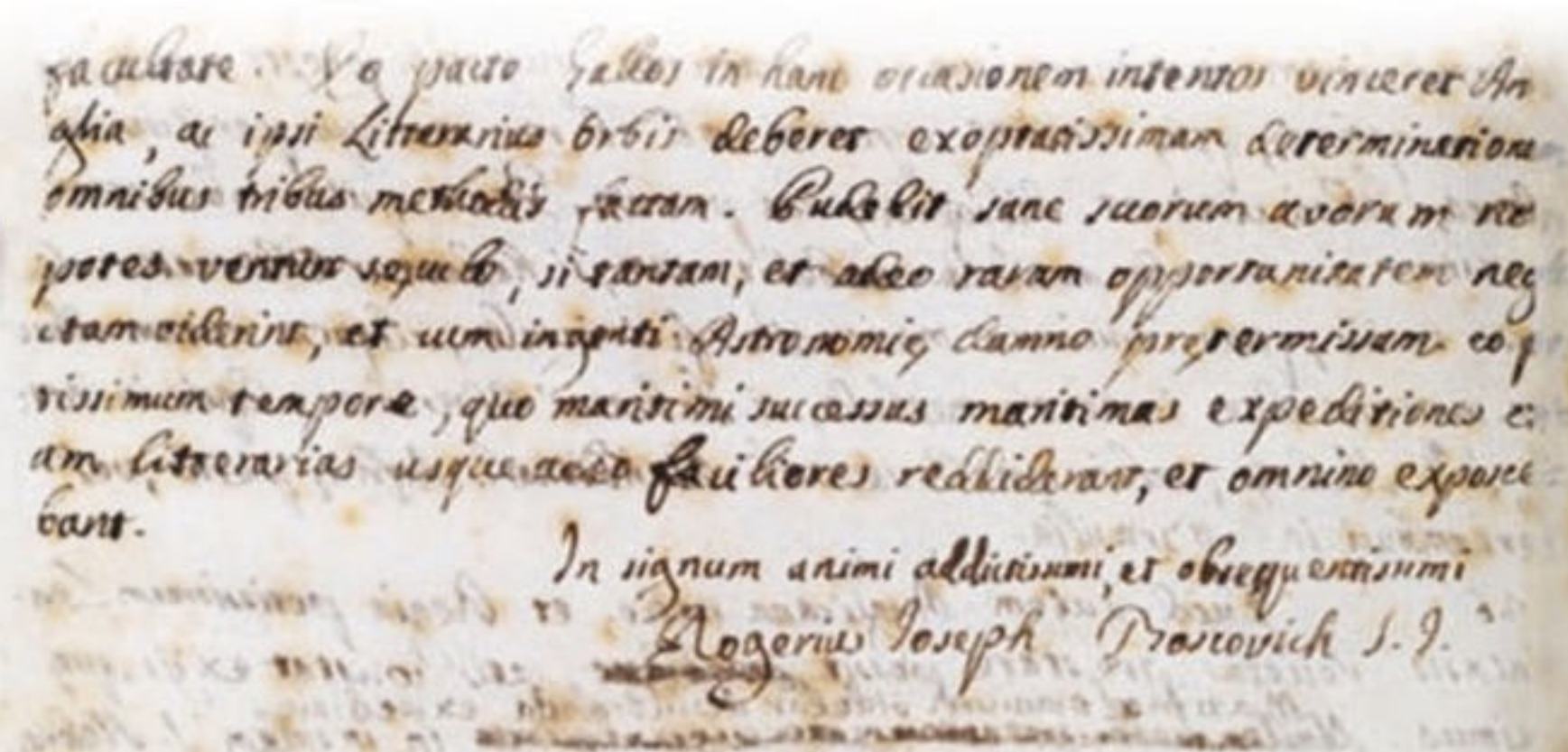


19^{DEC}

Roger Boscovich And The Royal Society

He was director of the Milanese Brera Observatory, came up with his own theory of how forces behave in 1758, and proposed how to stop St Peter's dome in the Vatican from falling apart. Yet few will have heard of the Croatian polymath Roger Boscovich. On the 300th anniversary of his birth and 250th anniversary of his Royal Society election, this exhibition lets you pore over his works.

Royal Society, London, until 15 February, free, visits by appointment only, j.mp/Boscovich



30^{DEC}

Plane Crazy

If your paper planes always nose-dive, then join this family workshop to get some tips. You'll make several different models, including the design for the world's current record holder. **Science Oxford Live**, 11am/2pm/3.30pm, £5 per person or £16 family ticket, j.mp/PaperPlanes



2^{JAN}

The Power Of Making

From building that first Lego house as a wee small child to proudly hammering the last nail into the new garden shed, people are always trying to make something. Without the ability to solve problems, invent and build things, all of our ideas would be no more than, well, ideas. Whether you're Mr Odd-Job or have two left hands, visit this exhibition to discover the different methods and materials that have been used to make ideas come to life, in fields ranging from medicine to social networking.

Victoria and Albert Museum, London, until 2 January, free, j.mp/PowerMaking



LAST CHANCE TO SEE

3 JAN

Astronomy Courses At The Royal Observatory

Struggling to spot Taurus, Cassiopeia or Gemini? Sign up for the six-week beginners' astronomy course taught by the Observatory's top experts, introducing you to planets, stars, galaxies and cosmology. You'll get hands-on with all sorts of equipment, including the UK's biggest visual refracting telescope, and get a chance to use the state-of-the-art digital planetarium. For those with some previous knowledge, the Further

Astronomy course explores the wider Universe and examines the big questions about the cosmos that still baffle astronomers. Or there's the 13-week Exoplanets course, focusing on worlds outside our Solar System, during which you'll have regular face-to-face contact with your tutor and fellow students.

Learning Centre, Royal Observatory, London,
www.nmm.ac.uk, 020 8858 4422

11 JAN

Newton's Last Alchemist: Medicine, Empire And The Birth Of Gin

Gin evolved from the juniper-flavoured liquor genever. A Dutch chemist created it in the late 16th century, and sold it for medicinal purposes. This talk explores how genever was instrumental in shaping medicine, politics and trade between east and west – and how it was consumed for the promise of immortality. As for the Newton connection is... you'll have to go along to the talk to find out!

Wellcome Collection,
London, 6.45pm, free, www.wellcomecollection.org/events



11 JAN

Professor Wendy Barclay

What's she talking about?

Influenza – aka 'flu'. If you haven't had a flu jab yet, you'll want to after this lecture. In her talk Wendy Barclay explains the mechanics of the flu virus, discusses the science behind the research she carries out in her lab and reveals the havoc pandemics can wreak. Not one for the hypochondriacs.

Who is she?

Wendy Barclay is a Professor in the Department of Medicine at Imperial College, London, where she holds the Chair in Influenza Virology. Her current research focuses on respiratory viruses, in particular (of course) influenza. Her research is used to help create new vaccines to fight pandemics.

Why should I go to see her?

As winter's frosty fingers truly take hold, the flu season will be in full swing. But how much do you really know about this most common of diseases? Barclay will cut through the media hype about epidemics and tell you how flu vaccines are created and what, if anything, you can do to avoid getting it yourself.

Wellcome Collection, London,
1pm, free, www.wellcomecollection.org/events



**SPEAKER
OF THE
MONTH**

12 JAN

Messengers From Mars

It'll be a few years before humans step onto Mars. In the meantime, we can learn about its make-up from samples collected by robotic rovers and by studying Martian meteorites. Join mineralogist Natasha Stephen as she explains how we know these meteorites actually come from the fourth rock from the Sun – and reveals why Mars is not really a red planet after all (it's actually only the dust on its surface that's red).

Natural History Museum, London, 2.30pm, free,
www.nhm.ac.uk/nature-live

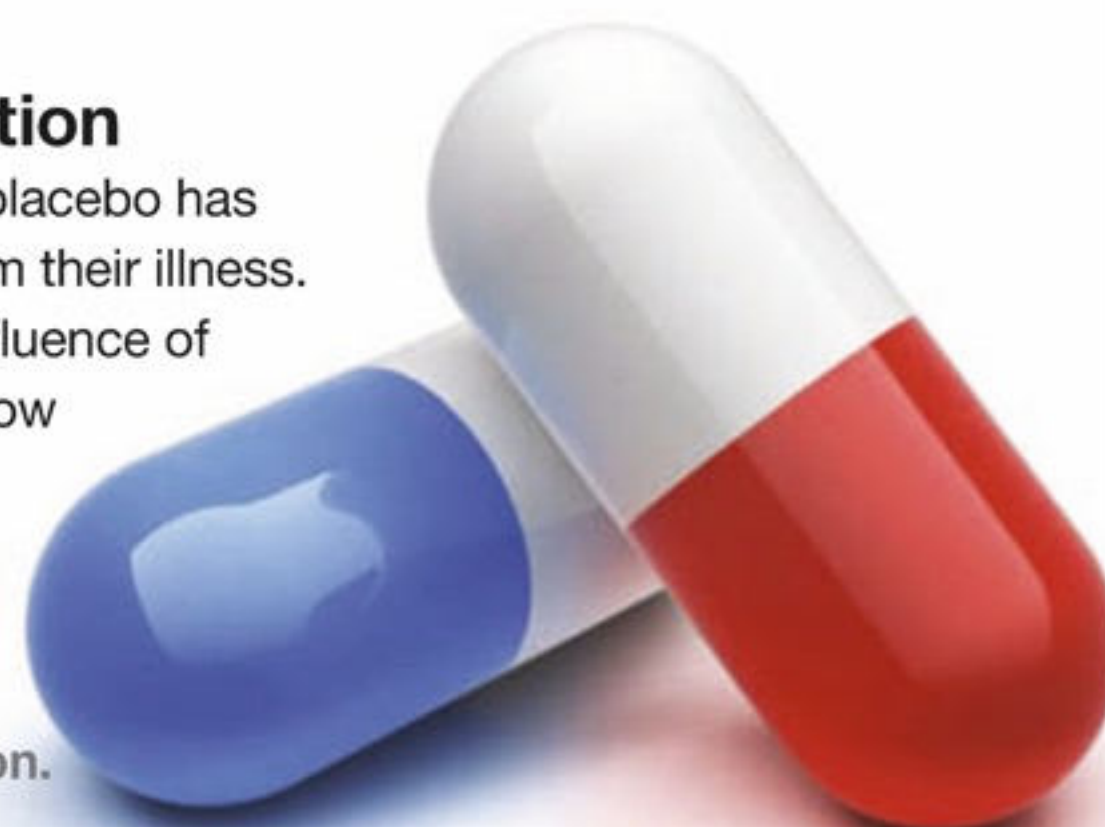


12 JAN

Cures Of Conviction

Many a patient given a placebo has made a full recovery from their illness. This talk explores the influence of mind over matter, and how what we believe can affect how we heal.

Wellcome Collection,
London, 7pm, free, www.wellcomecollection.org/events



TV & RADIO

The month's top science programmes

Megaquake 10.0



History

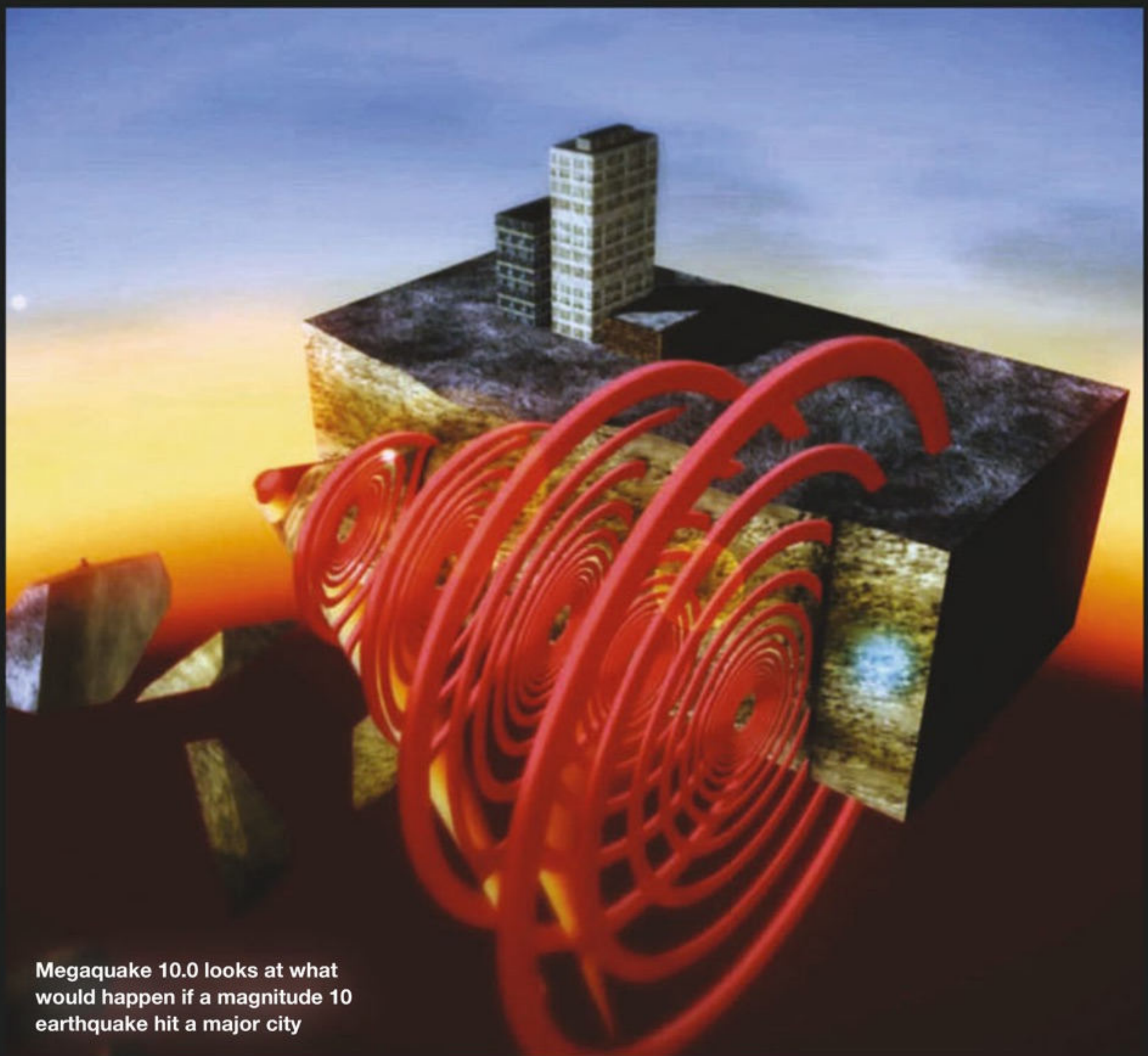
30 December, 9pm

Every time there's a big earthquake, it feeds the fears of people living in vulnerable areas – which means up to three billion people.

The earthquake that devastated Japan in 2011 was of magnitude 8.9. The most powerful quake ever recorded, off the Chilean coast in 1960, measured 9.5.

This two-hour special asks what are the chances of a magnitude 10 'megaquake' hitting somewhere like the west coast of America? And if it did, what would the consequences be? Not good, is the short answer. Skyscrapers and suspension bridges would tumble (and do, in animations that are begging to be part of a videogame). And the aftermath of the Japanese quake and tsunami shows how the immediate danger then turns into painful long-term rebuilding.

At least California won't be falling into the sea any time soon – a magnitude 10 quake there is highly unlikely. If California goes anywhere it's more likely to keep sliding north towards Alaska. So Americans, at least, can be a little more relaxed during the disaster sequences.



Megaquake 10.0 looks at what would happen if a magnitude 10 earthquake hit a major city

Underwater Universe



History, starts 31 December, 9pm

Watch all four episodes of this series and you'll never don a swimsuit again. The oceans may remain largely unexplored, but it seems that they mainly consist of ways for you to die.

First, tsunamis and freak waves, which have proved their deadly effects only too recently. Next, the top five predators that want to eat you, but aren't too busy to hurt you quite a lot along the way. Then we have deadly tides and currents, now blamed not only for the odd hit-and-run drowning, but also for mass extinctions in the distant past. And finally there's pressure, the simple law of physics that makes survival in the depths as impossible for humans as it would be in outer space.



Monsters Resurrected



Discovery HD, starts 18 December, 7pm

The Mosasaur, with six-foot jaws and a spare set of teeth, picked fights with sharks and 40-foot-long dinosaurs in oceans that covered 85 per cent of Earth. But that's nothing. Terror Bird had an 18-inch beak and swallowed giant rodents whole. No sabre-toothed cat ever gobbled *him* off a bird table. Even if anyone had been around to build one, which they weren't.

Anyway: disappointingly, nobody is about to physically resurrect these beasts. Instead, this series brings you some very clever TV recreations of the most alarming predators from prehistory. These two and others like them will snarl, slash, chomp and chew their way across your screens until you're very glad indeed to be alive now, and not when they were around.



Yeti's Finger

BBC Radio 4

27 December, 11am

An American oil tycoon called Slick, on a mission to prove that yetis do exist, bribes some Buddhist monks to get a dead finger he believes belonged to one of these fabled beasts. A Hollywood star smuggles the finger from Tibet in his wife's lingerie case, only for it to lie forgotten in a museum in London. It could be an Indiana Jones plot, but it's a true story. And now the rediscovered finger can be tested by modern science to see what kind of creature it did belong to.

Don't Log Off

BBC Radio 4

2 January, 11am



Alan Dein was the man who rang telephone boxes late at night in *Don't Hang Up*, back in 2007. People answered, which opened up remarkable conversations with lonely Floridian security guards and New Zealand transsexuals. Now Dein tiptoes into the 21st century, abandoning the telephone in favour of the video chatroom. Who will he find there, willing to engage in the most revealing exchanges with a complete stranger? He doesn't know, and nor do we – that's part of the appeal.

Thinking Streets

BBC Radio 4

3 January, 9pm

If you've been to the Science or Natural History Museums lately, you may have noticed the streets mutating, losing their boundaries with pavements. It's all part of a big experiment in human psychology that started in the Netherlands. What would happen if they took out all the traffic signals and left drivers to use their initiative? What happened was that accidents went down. This programme examines the newest trend in urban design and asks if it can make us all safer.

Buggin' Out



Animal Planet

17 and 24 Dec, 9pm



Ken the Bug Guy, wife Georgi and best friend Mike the Scorpion King may sound like obscure comic-book heroes, but their work at America's biggest insectary is in demand. It could be 40 scorpions for a photo shoot or sourcing something "big, scary but harmless" to help a therapist treat a phobia. Then it's the annual tarantula conference, at which Ken and Georgi's two-year-old daughter will debut her racing cockroaches...

The True Story



Discovery

Starts 1 Jan, 9pm



If you often find yourself sitting in the cinema thinking, "I wonder how much of this is true?" then you won't want to miss this series. Unravelling the stories and the science that underlie Hollywood blockbusters, it seeks out the real people behind the screenplays, consults experts in the field and even stages the odd experiment. Among the films dissected are *Close Encounters Of The Third Kind* and *Apollo 13*.

Lost Tomb Of Genghis Khan



National Geographic

28 Dec, 9pm

Legendary warlord Genghis Khan was so keen to lie undisturbed through eternity that the slaves who constructed his tomb were killed – and the soldiers who killed them also massacred. For 800 years, his tomb has eluded archaeologists. Now, self-confessed Genghis obsessive Albert Yu-Min Lin leads an expedition to find it, defying freak weather and grave-robbing bandits on the sacred mountain of Burkhan Khaldun.



Stargazing LIVE



BBC Two

16-18 Jan

After the success of last year's UK-wide astronomy-fest, Dara Ó Briain and Brian Cox return with an all-star lineup including Liz Bonnin and... you! The programme of live skywatching events around Britain hopes to lure you off that warm sofa and out to observe the heavens with your local astronomers. So go out and gaze at stars, or stay in and watch others gaze at stars. Your choice.



Tallest Towers



National Geographic

29 Dec, 8pm



The chance to set a new record by building the world's tallest building is an architect's dream. But for César Pelli and his team, the dream sometimes felt more like a nightmare. His design for the Petronas Towers in Kuala Lumpur was chosen to embody the optimism of Malaysia but the pair of 88-storey skyscrapers went up in only four years, with teams working night and day and GPS to keep the buildings vertical.

Expedition Wolf



BBC One

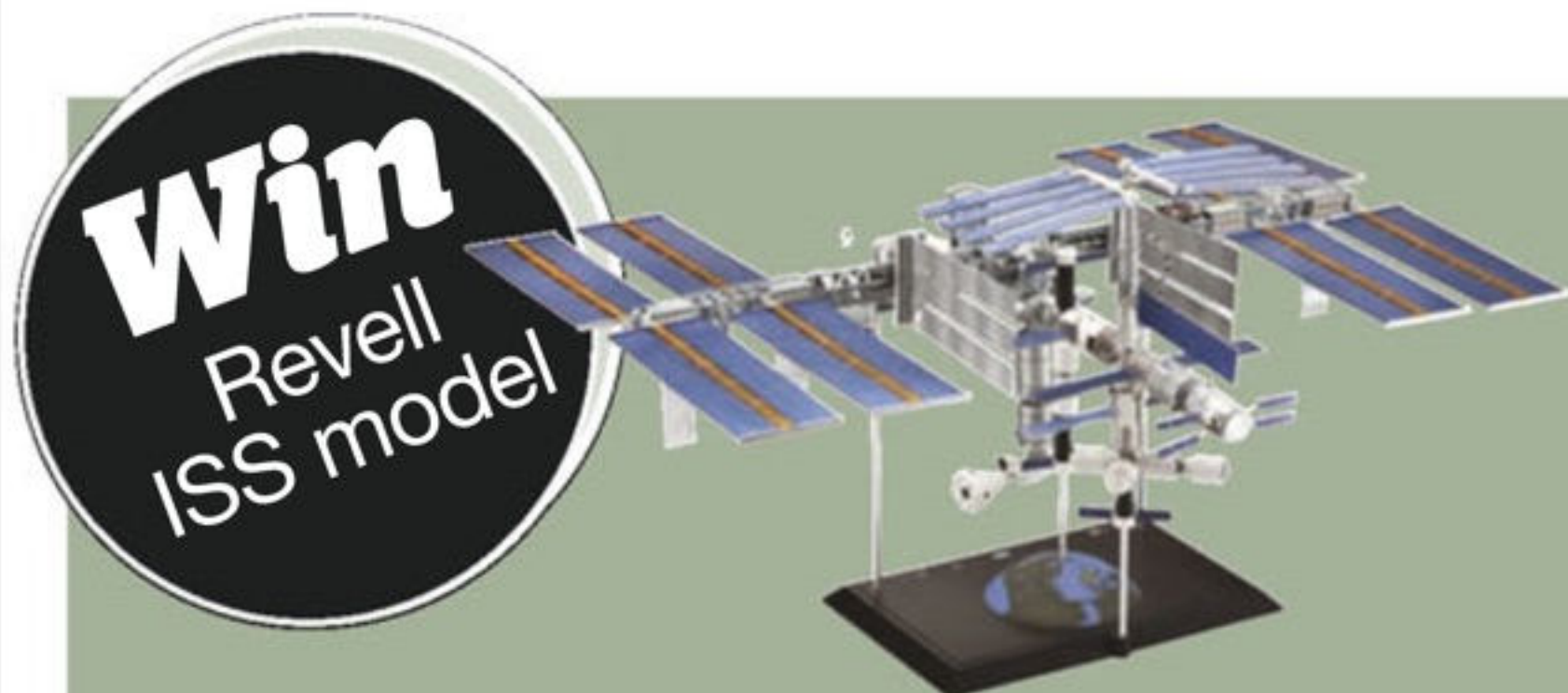
TBC



Wolves are returning to the USA. Once hunted nearly to extinction, wild packs now come close enough to cities like Seattle to make the human population feel uneasy, and the wolves are being shot once again – by cameraman Gordon Buchanan. Skidoos, sleds and snowshoes help him across the wolves' terrain, but they'll also need some expert insights and a dollop of animal cunning to track down nature's finest trackers.

BRAINTRAINING

Pit your wits against these brainteasers by **David J Bodycombe**



Win
Revell
ISS model

See bottom of p109 for terms and conditions. Congratulations to Carol Beckett (Pembrokeshire) who solved October's prize puzzle and will receive a Revell Discovery Shuttle model kit.

Prize Puzzle

Work out what mathematical function is being applied, then complete the final line:

6061 → 4152
8016 → -1092
9608 → 1512
1698 → ????

The first correct entry drawn from the *Focus* hat will win an International Space Station model kit from Revell. Visit www.revell.eu to see the full Revell range. Send your entry, marked 'Prize Puzzle 237', to the address on p109 by 12 January 2012. We regret we cannot accept email entries.

See sciencefocus.com/winners for previous winners and solutions

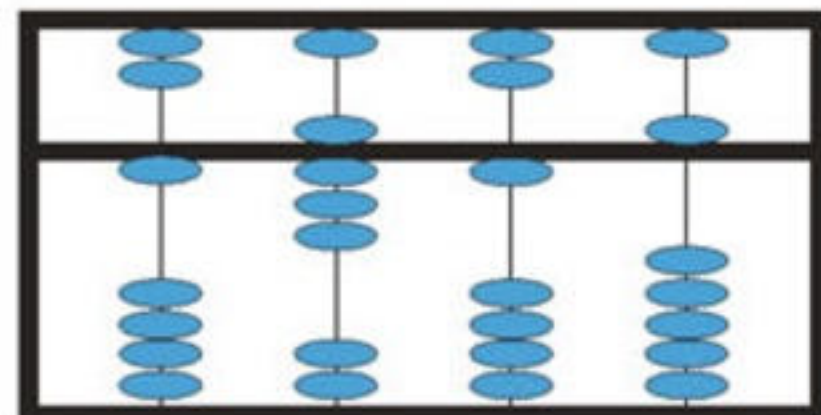
QUESTION 1

Which letter continues this logical sequence:

T, H, T, TT, HT, _?

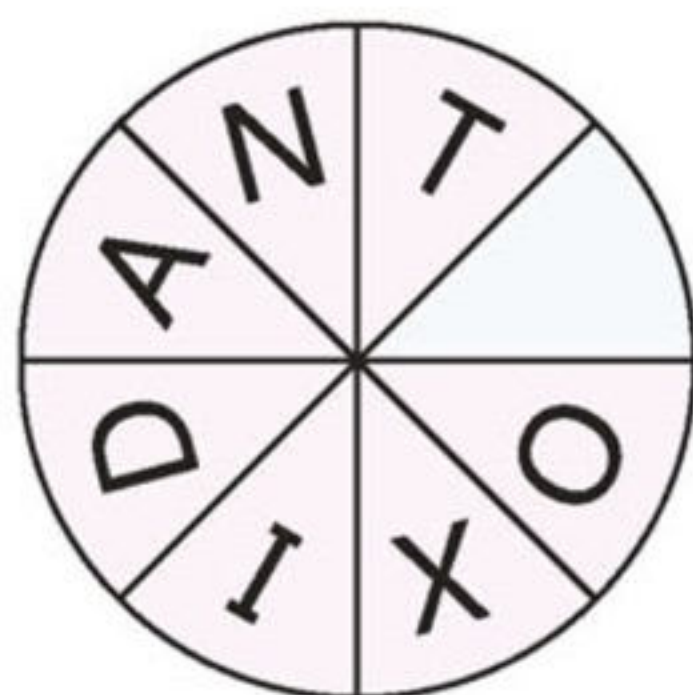
QUESTION 2

What famous historical event is most closely associated with the year shown here?



QUESTION 3

What letter should go in the blank so that the longest word possible can be read round this circle?

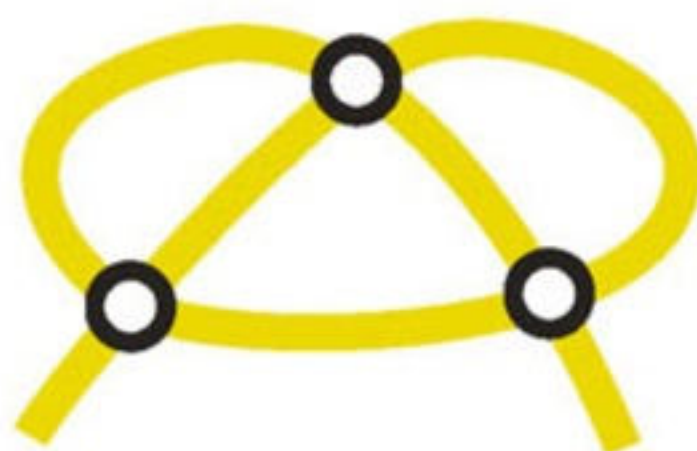


QUESTION 4

The standard version of which object, found in the majority of households, contains 42 eyes?

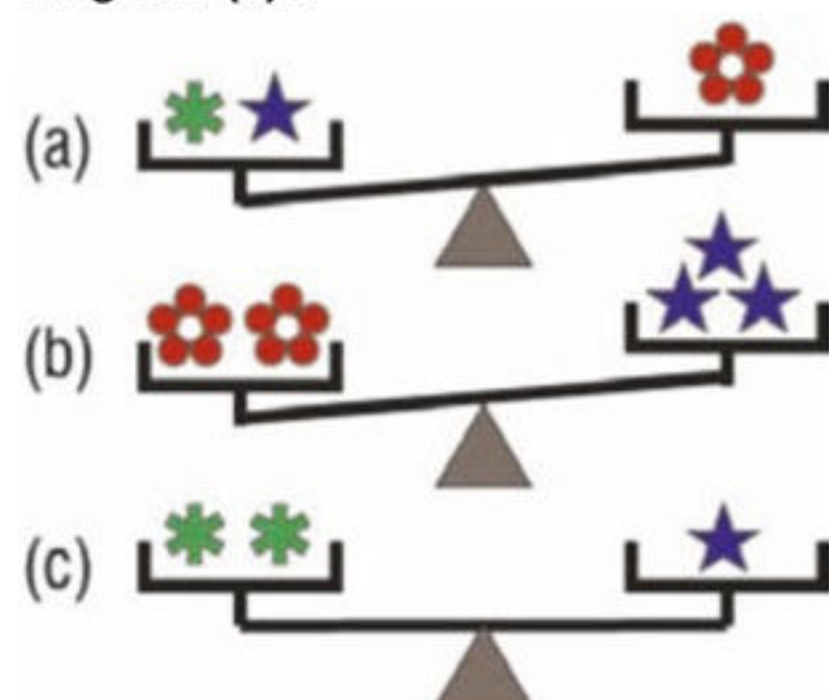
QUESTION 5

A rope has been hidden under three discs at the points where it crosses over itself. What is the probability that the rope makes a knot?



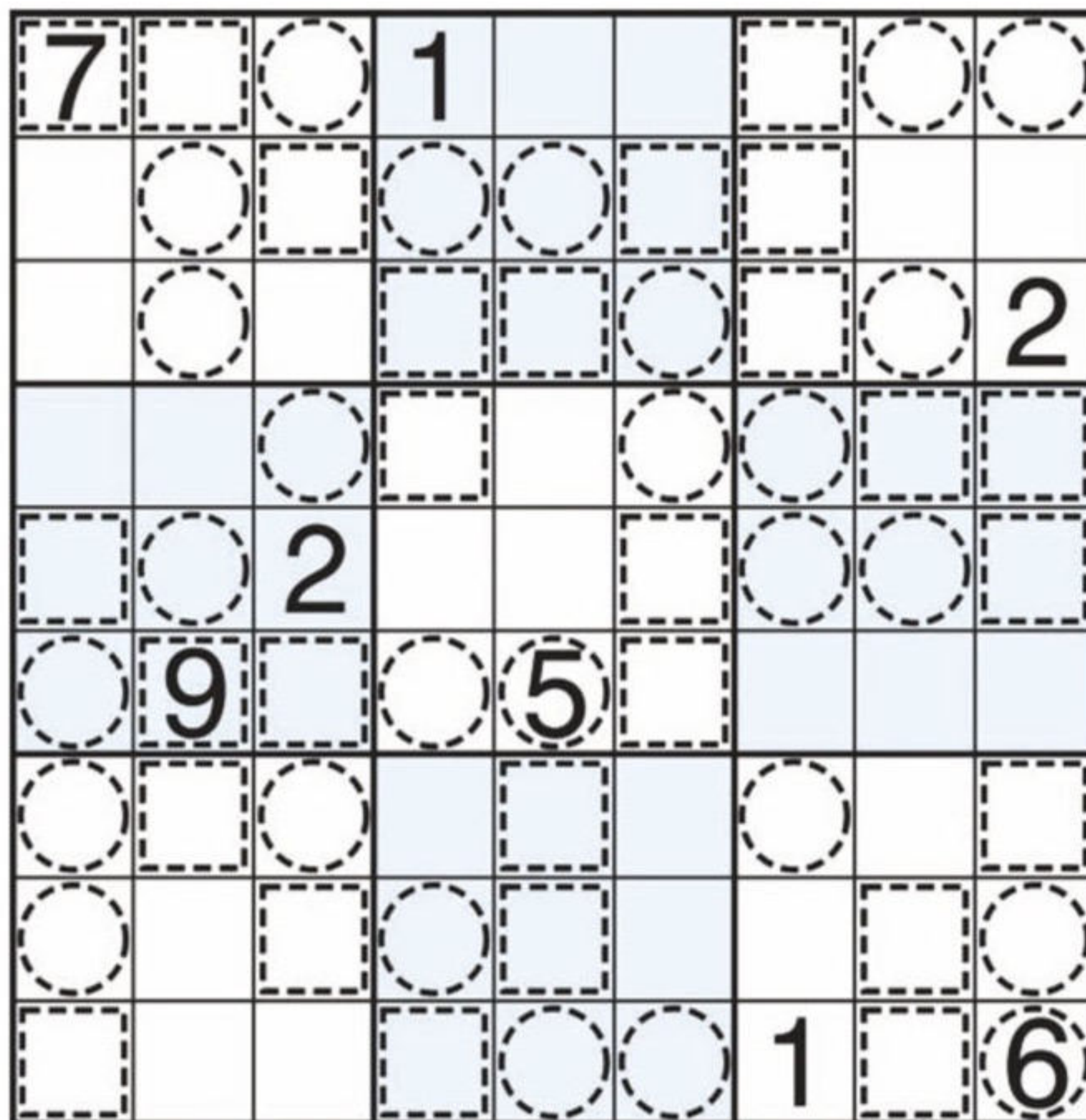
QUESTION 6

Which way will the scales tip in diagram (c)?



QUESTION 7

In this variation on a sudoku puzzle, every row, column and 3 x 3 box (marked by the heavier lines and shading) contains the numbers from 1 to 9. In addition, the symbols tell you extra information: an unmarked space contains 1, 2 or 3; a dotted circle contains 4, 5 or 6; and a dotted square contains 7, 8 or 9.



7	8	5	1	3	2	9	6	4
2	4	9	5	6	7	8	1	3
3	6	1	9	8	4	7	5	2
4	1	8	6	7	3	2	9	5
5	7	6	2	9	1	4	3	8
6	9	7	4	5	8	3	2	1
8	5	2	3	1	9	6	4	7
1	3	4	7	2	6	5	8	9
9	2	4	9	5	6	7	8	1

Q1) M for million (Ten, Hundred, Thousand, etc.) Q2) The year is 1815, the battle of Waterloo. The lower beads near the central bar count as 1, the upper beads count as 5. Q3) I, giving the word ANTIOXIDANT. Q4) A pack of cards. Q5) 25% (or 1-in-4, or 3/1). At each of the three crossover points, the rope can go under or over itself, giving eight possibilities. Of these, two make a knot. Q6) The left pan is heavier. If (a) A + B > C, and (b) 2C > 3B, then 2A + 2B > 2C > 3B. Hence, 2A > B. as per diagram (c). Q7) See illustration, right.

Solutions

Quick Quiz

How well do you know the elements?

QUESTION 1

Which element has the highest melting point?

- a) Carbon
- b) Plutonium
- c) Zinc



QUESTION 2

Which element can be found in yellow paint?

- a) Lithium
- b) Cadmium
- c) Thallium

QUESTION 3

Which of these is not a metal?

- a) Krypton
- b) Sodium
- c) Lithium

QUESTION 4

What was used to poison Aleksander Litvinenko?

- a) Plutonium
- b) Polonium
- c) Potassium

QUESTION 5

Which of these isn't an element?

- a) Einsteinium
- b) Californium
- c) Britainium

QUESTION 6

What is the most abundant element in the Universe?

- a) Argon
- b) Chlorine
- c) Hydrogen

QUESTION 7

What was the first artificially produced element?

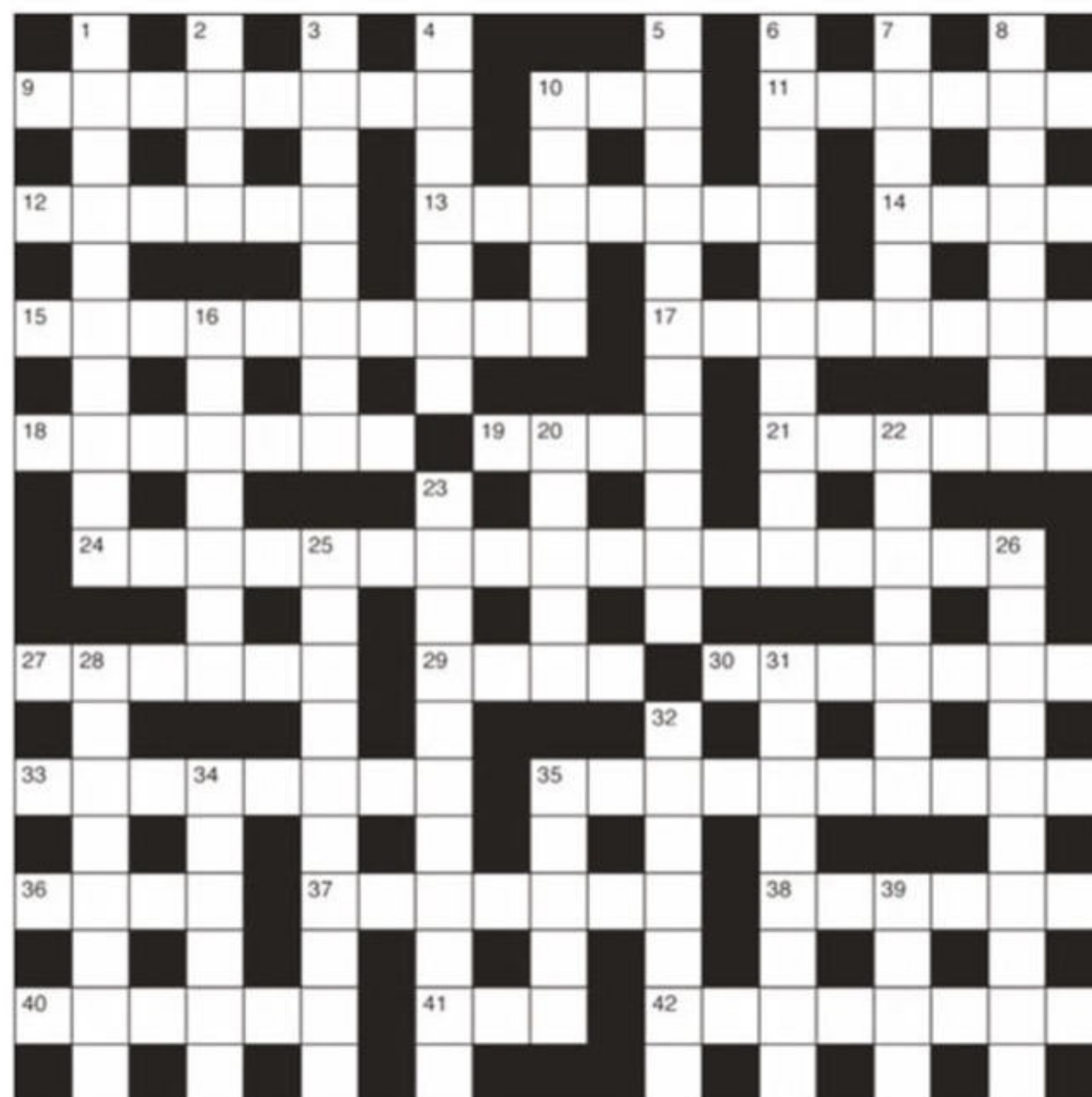
- a) Technetium
- b) Manganese
- c) Tantalum

YOU ARE:

0-2 Elementally challenged
3-5 Periodically acceptable
6-7 Top of the table

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Focus crossword N° 136



Across

- 9 Particle accelerator bent round (8)
- 10 Frenchman finds a key in a coat (3)
- 11 Writer gives gold to deity (6)
- 12 Underwear attracts right crowd (6)
- 13 Tree has major disorder (7)
- 14 Heard to ask for a victim (4)
- 15 Mistake by master turned into racing advantage (10)
- 17 Whole thing gets about (8)
- 18 Work on a sentence to make it iridescent (7)
- 19 Mineral of comical interior (4)
- 21 Hereditary material has facts only on yours truly (6)
- 24 Brief musical follows family pet (8,9)
- 27 Mark gets sailor a beetle (6)
- 29 Primate gets a kiss at the top (4)
- 30 Twice, fellow got a fodder plant (7)
- 33 Smoker disperses mob with British explosive (4,4)
- 35 Cart madam off around a particular surface (10)
- 36 Collapsed round part of church (4)
- 37 Can fellow get lubricant that's used in the oven? (7)
- 38 Sunny outside – it is limited (6)
- 40 Flag points to gesture (6)
- 41 Fictitious bird is included (3)
- 42 Best 60s group started way of maintaining access (8)

Down

- 1 Pooch paled alarmingly on seeing squid, say (10)
- 2 Harold only gets a ring to show how good he is (4)
- 3 Bishop reaches trendy resort (8)
- 4 Photograph for every tropical fish (7)
- 5 Car part used to race clear away (11)
- 6 Drink to get drunk without loopholes (10)
- 7 Proust's terrible dullness (6)
- 8 Force time with hesitation (8)
- 10 Reversible note (5)
- 16 Perspex, say, quietly performing my role (7)
- 20 Children's edition (5)
- 22 A grain floating on a river (7)
- 23 A crab bone – it improves with salt (11)
- 25 Program part often used in underwater craft (10)
- 26 Engineers bit of change in wave's direction (10)
- 28 Cutting distortion (8)
- 31 Game involving pale amphibian (8)
- 32 Puritan accepts the Spanish introduction (7)
- 34 Cite me incorrectly? It makes me sick (6)
- 35 Swimmer's new tutor (5)
- 39 Unfortunately sent home (4)

Solution to N° 133



Congratulations to AP Coniam (Gillingham), Kathy Humphrey (Crewe), John Green (Kettering), Peter Haworth (Bristol) and Stephen Kloppe (Croydon) who all completed October's crossword (no 133) and each win a copy of *A History Of The World In 100 Objects*.

YOUR DETAILS

NAME:

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POSTCODE:

TEL:

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Send your entry to *Focus* at the address below. Entrants must supply to Immediate Media Company Ltd their full name, postal address and daytime telephone number. Immediate Media Company, publisher of *Focus*, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' if you prefer not to receive such information by post or phone. Please write your email address on your entry if you prefer to receive such information by email.

Send your Prize Puzzle and Crossword entries to:

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The first five correctly completed crosswords drawn from the *Focus* hat will each receive a copy of *Frozen Planet* on DVD. Send your entry, marked 'Crossword 136' to the address below by 12 January 2012.



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Background Image: A Liverpool Telescope image of Comet C2002T7

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me-flow Blake Taylor *an electromagnetic revolution*

me-flow is a book in two halves. One is a chronological history of physics from Ancient Greece to quarks. It highlights discoveries which unlocked the mysteries of, or exposed the great illusions of, the universe. At the same time it explores the personalities and often peculiarities of the pioneers of science.

The other half relates to the authors theory of space.

In 1887 Michelson and Morley proved experimentally that the speed of light is constant in space, irrespective of the motion of the source or the receiver. From this they concluded that the *ether* didn't exist; 'empty' space was absolutely empty. An modern alternative conclusion is: *'what is there, be it real or virtual, does not affect the speed of light.'*

me-flow explores the latter, building the properties of space into a dimensional universe rather than, (*but not contradicting*) a mathematical quantitative one.

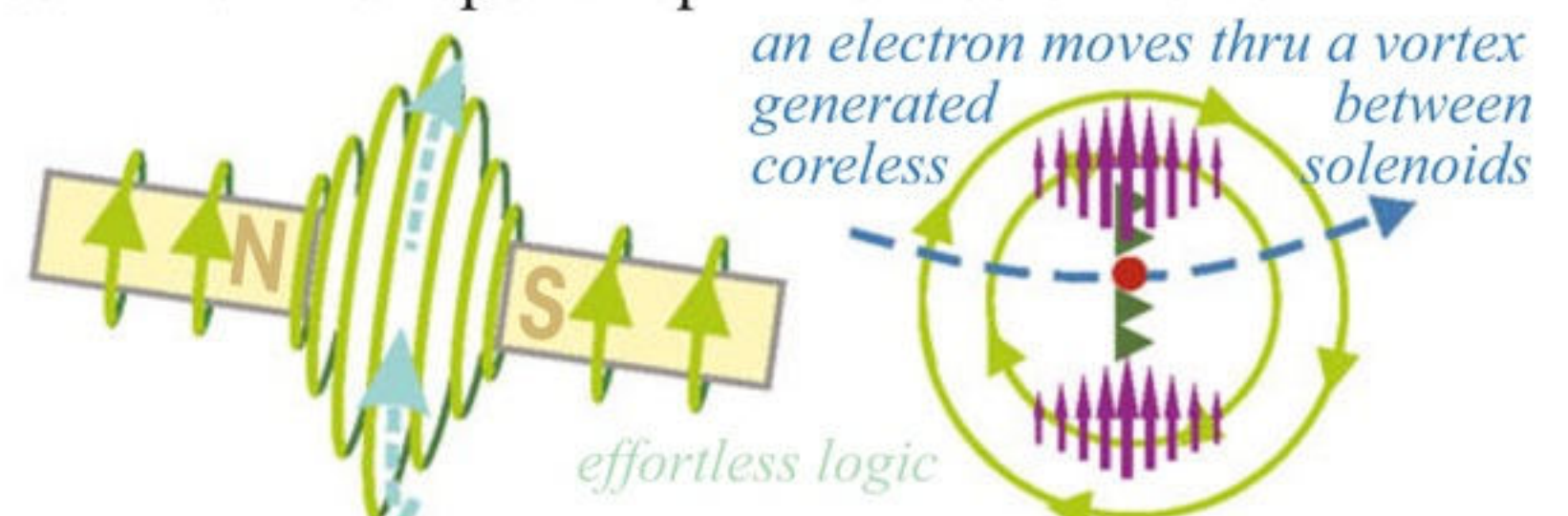
The forces respectively between charges or masses, are inversely proportional to the intersection of the volumes of space each influences, divided by their distance of separation. *same maths - but now a tangible image.*

$$F \propto \frac{1}{Vol/d} \propto \frac{1}{d^3/d} \propto \frac{1}{d^2}$$

Magnetic space surrounds its generating current and flows parallel, *not perpendicular* to it. Bernoulli forces apply. Co-parallel motions attracts - anti-parallel motions repel.

Coils generate vortexes of magnetism about their axes. Solenoids and/or magnets with like spinning vortexes attract each other; *counter spins repel.*

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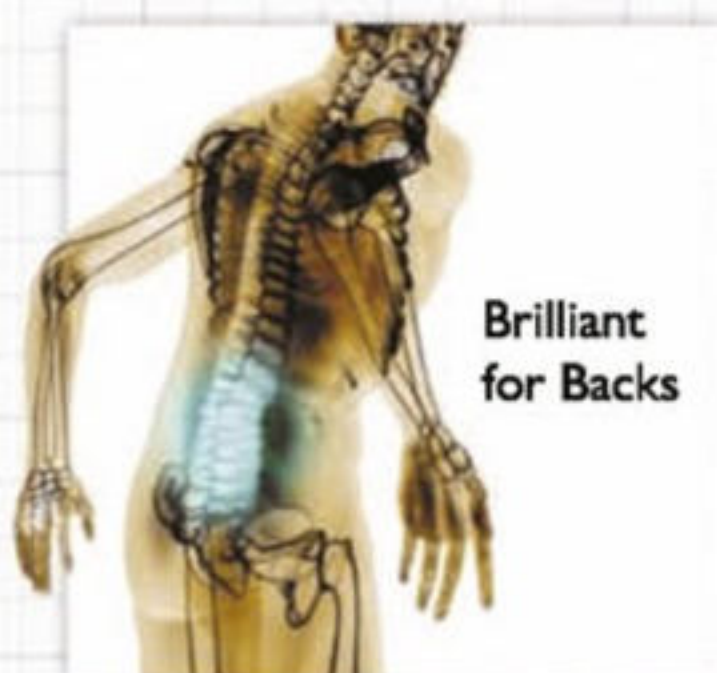
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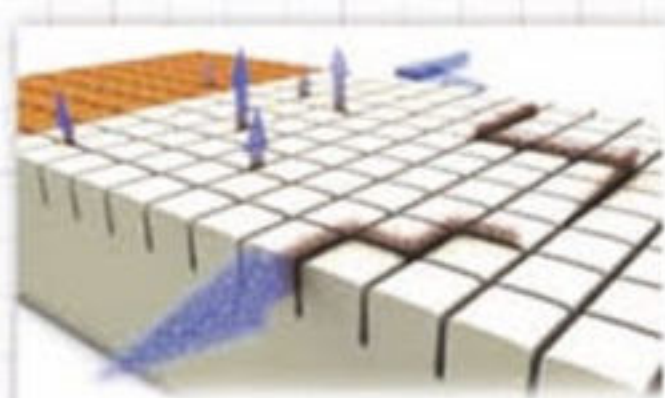


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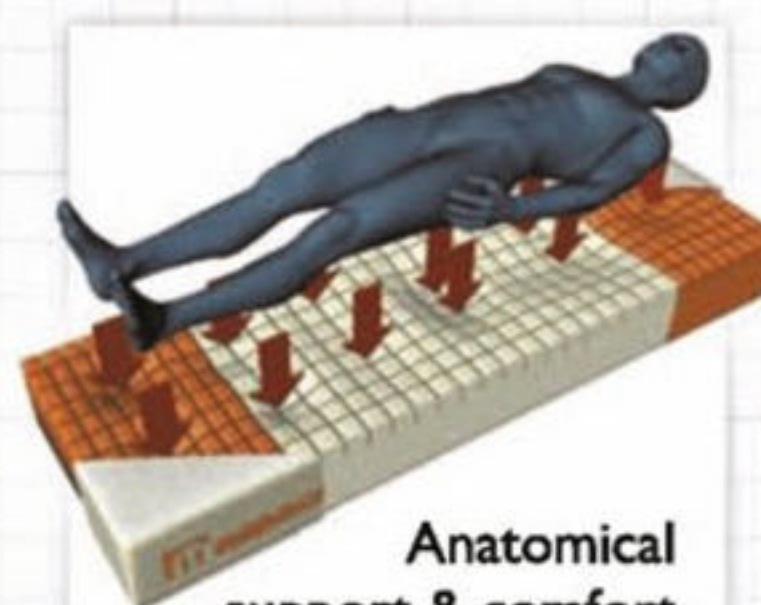
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There is a theory that suggests **human intelligence evolved from our ability to deceive others**

page 79



Dust from the Sahara desert can probably be found under every bed in the world

page 71



A Kindle filled with ebooks weighs more than an empty one

page 19



page 58

Songdo, a new city being built in South Korea **won't have rubbish collections.** Instead, all waste will be sucked away through tubes



A pound of **fat** contains more energy than a pound of **dynamite**

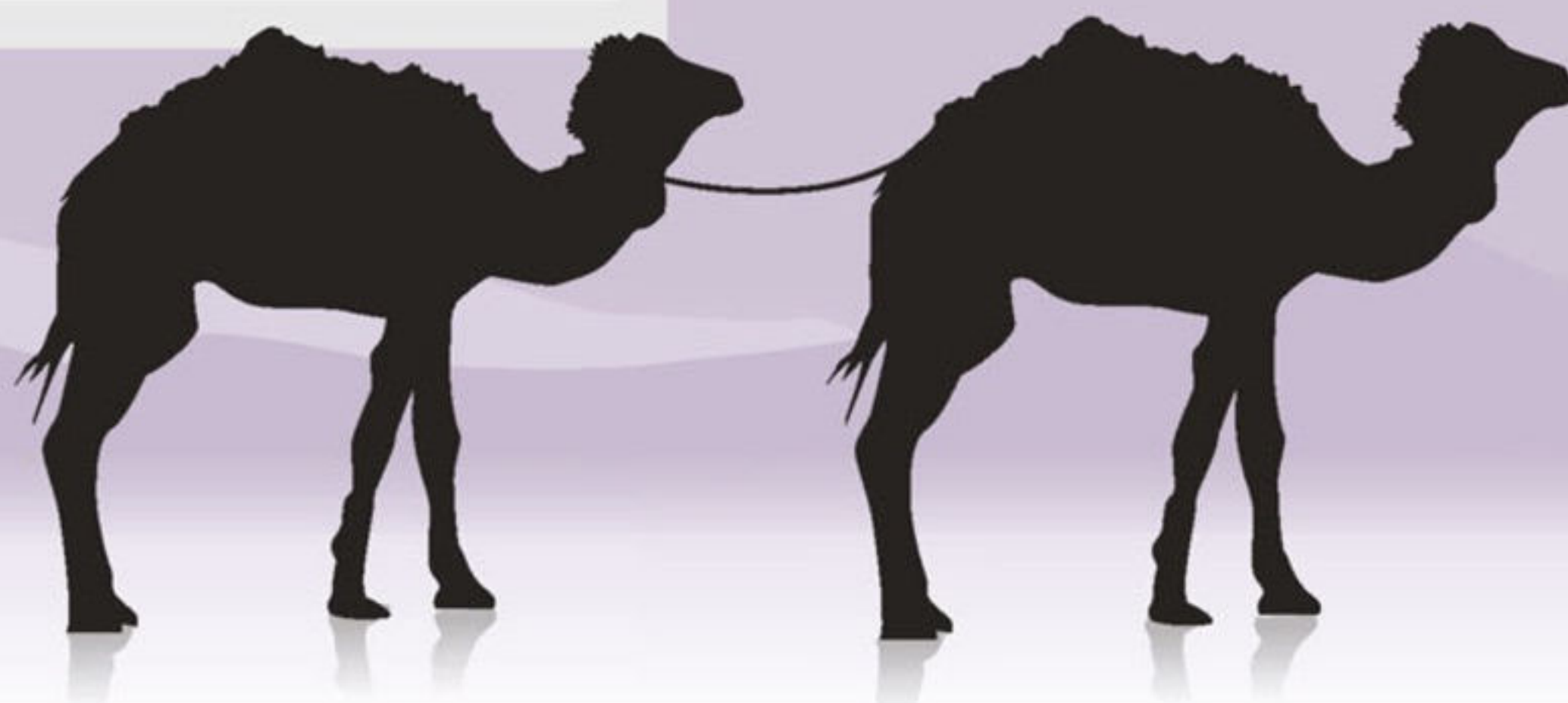
page 46



Even camels that live in waterless deserts are capable of swimming

page 76

Pool: 3,000km



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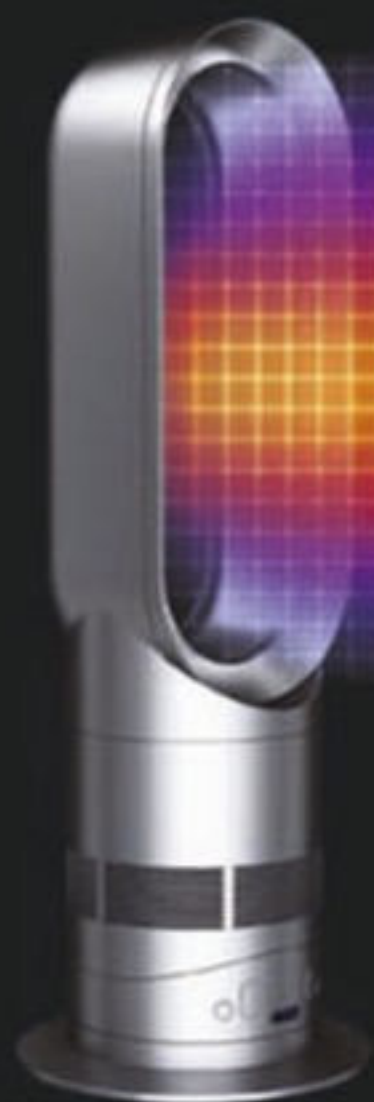
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